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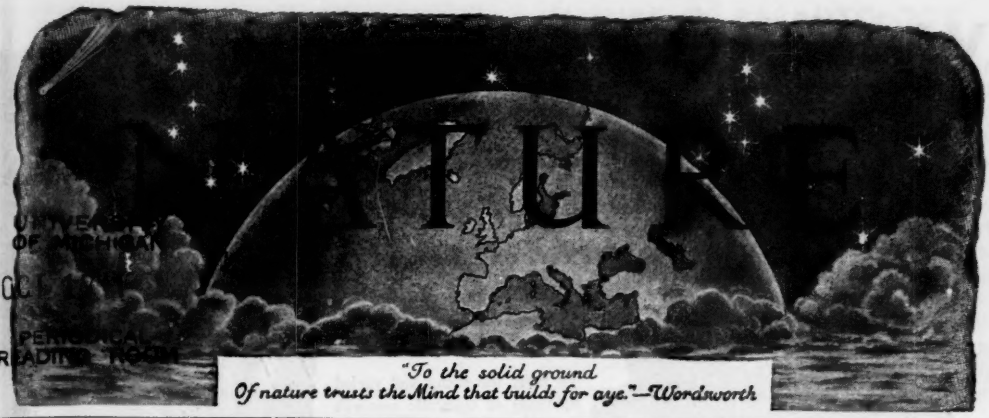

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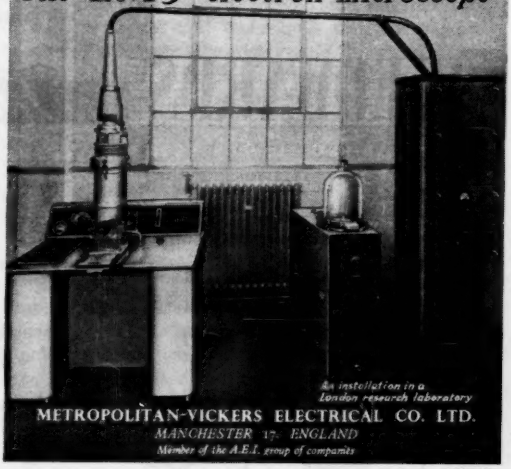

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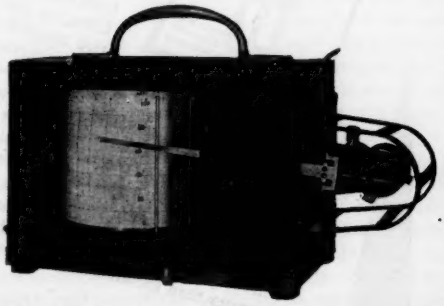

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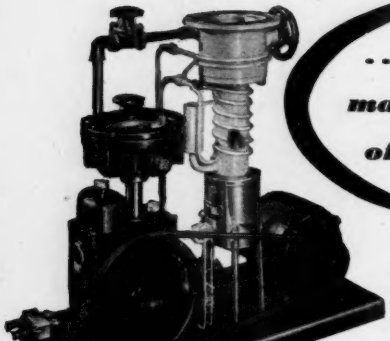

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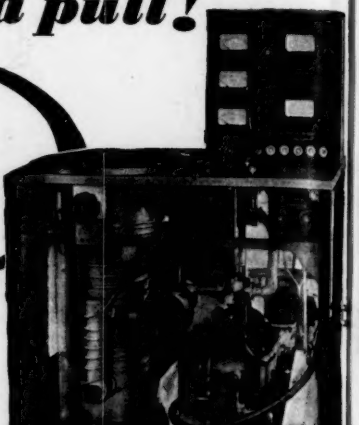

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FUTURE OF PARASITOLOGY

IN the early part of the present century, and to some extent, no doubt, earlier than this, the minds of zoologists, influenced by the rapid growth of those promising infants, biochemistry and biophysics, ceased to find inspiration in the great investigations of animal structure which are the glory of an earlier biology, and transferred their energies to physiological and experimental work. The science of experimental zoology was born and after a period of adolescence during which, with pardonable pride, it seemed to believe that morphology was no longer worth serious effort, it settled down to change the trend of biological research and incidentally to bring back, not the old morphology, but new conceptions of structure required, at different levels, by experimental study.

By the same process, by a shift from the static to the dynamic, from architecture to physiology, the outlook of parasitology is also being changed. The germ of this change was latent in the work of some of the older parasitologists who sought, but inevitably in vain, concepts and techniques which could only be found when biochemistry and biophysics were mature enough to make them available. But the new and powerful techniques were vigorously taken up for the study of parasites, and for some time now, in the pages of *Parasitology* and in those also of journals not specifically devoted to the study of parasitic life, a growing volume of experimental work upon parasites has been printed. It is not surprising, therefore, that a need has arisen for a journal devoted entirely to work of this kind. The new quarterly *Experimental Parasitology* (Acad. Press, Inc., 125 East 23rd St., New York), the first issue of which is to appear shortly, will help, by concentrating experimental work on parasitic organisms in one journal, to bring this kind of work to the attention of all biologists.

The scope and outlook of the physiological, experimental and immunological work now being done on parasitic organisms cannot be properly discussed in the space available here. Its literature is already voluminous and takes us back to surprisingly early dates. An idea of its quality, and of the fundamental problems that it raises, can be obtained from summaries of various aspects of it that have recently appeared. Thus Hobson[1] and Read[2] are concerned with our growing knowledge of the physiology of nematodes parasitic in the alimentary canals of their hosts, and their summaries show that the experimental study of these organisms is extending our knowledge, not only of the nematodes, but also of the biochemistry of the alimentary canal. Smyth[3] and Wardle[4] review what we know of those tapeworms the physiology of which has been investigated. Lwoff, and the distinguished contributors to the book[5] which he is editing, deal with the physiology of both parasitic and non-parasitic Protozoa, and thus enable us to make those direct comparisons between the biology of closely related free-living and parasitic organisms which throw so much light on the

basic phenomena of life. Smyth, in common with the protozoologists, has, thanks to his own remarkable success in cultivating a tapeworm, had the advantage of study of a parasitic animal *in vitro*. As Read[3] and Lapage[4,7] have pointed out, the cultivation of a parasitic nematode in a sterile medium, when this becomes possible, will quickly increase our knowledge of these remarkably adaptive organisms. A technique for the experimental study of them free from bacteria is urgently required and, when it is available, we may expect not only better knowledge of nematode physiology but also valuable additions to general biology. In addition to work on helminths and Protozoa, there is, as every biologist knows, a great deal of similar work on the parasitic arthropods. Of fundamental importance also is the growth of modern contributions to the immunology of parasitic infestations, the study of which is making such rapid progress nowadays.

All this work, in one degree or another, fulfils the biological maxim that the animal cannot be properly studied apart from its environment. The protozoan in the blood, the helminth in the gut, the scab-mite in the skin, are all animals inseparable from those tissues of the host which they normally inhabit. The central problem, therefore, is the relationship of the parasite to its host. To the study of this, by one method or another, parasitology directs its energies. Important to it, without any doubt, are studies of those morphological and adaptational beauties of the parasite which still, we may congratulate ourselves, excite the interest and admiration of minds that are sensitive to them. Based also on the study of the host-parasite relationship is the economic work, the efficiency of which has gained so much from the modern outlook. We need not fear that, if we ask the parasitologist to be primarily a biologist, trained in biochemistry and biophysics, we shall lose, or delay, economic gains for which we hope. The greatest advances in our control of harmful parasites have come from the biological study of their activities. It is only common sense to believe that, when we know how the parasite breathes, feeds, excretes and uses, within its host and at its host's expense, whatever biochemical processes link it to that host, we may learn to control it, not by our present-day expensive use of dangerous drugs discovered rather by chance than by rational methods, but by attacks on one or other of the essential physiological links between the parasite and its host—a method which may turn out to be cheaper and much more effective.

This understanding of parasitic life, when we achieve it, will bring us, however, more than effective means of control. It will bring understanding of much more than parasitism. In the food canal, in muscle, liver, blood, in practically every tissue of almost every kind of animal, in the very cells of which the tissues are composed and even in their nuclei, some kind of parasite may live and wage with its host a battle that, in the course of evolution, ends frequently, not in the extinction of either the host or the parasite, but in a state of interdependence of one upon the other, in a mutual tolerance that may be scarcely distinguishable from the condition that we recognize as symbiosis. This conflict is based on physiology; its weapons are enzymes, ions, catalysts, antibodies. All the concepts of biochemistry and biophysics figure in its armouries. The study of it will, therefore, bring us wider knowledge of the basic processes of biology. It is not too much to hope that, when we understand, for example, the methods by which the nematode succeeds in living in environments so widely different as the sands of the seashore and the contents of the duodenum of a man or a ruminant, we may have uncovered much that is new to biology. It is not too much to hope that, when we understand the biology of the viruses, we shall have come nearer to understanding the origin of life upon earth. Meanwhile, if we are not dull, we shall, without doubt, have learnt how man may live in harmony with his own parasites.

The study of parasitic organisms, thus broadly conceived, becomes not merely the study of organisms that do harm to man and to the animals and plants that minister to human needs, with the limited aim of destroying these organisms so that man may prosper; but rather the biological study of a certain way of living, of one of the ways in which living things have come in the course of evolution to live together, of the value and interest of this way of living considered as an evolutionary device and of the basic problems that it puts to biology. It becomes the business of the biologist, and it is to biology that we must look for relief from the suffering, death and economic loss that parasitic animals cause.

If this is so, and if we wish this kind of work to be done, we must make it possible for the young biologist to do it. We need not try to persuade anybody to take up work of this kind. Men persuaded cannot do what men inspired will naturally do. There are, we must frankly recognize, young biologists who avoid the parasite because they have a horror of disease; there are others who are not 'amused' by parasitic life; there are others still who have worthier reasons for their interest in different fields; but for those who are naturally attracted to experimental work on parasitic organisms, are we doing all that could be done?

The problems posed by this kind of work are intricate and difficult. They cannot be made the shuttlecocks of scientific politics. They cannot be solved in the two or three years required for the acquisition of doctorates. They require a vocational drive that must have freedom for a period of years, years that will bring (unless there be lucky chance discoveries) failures, delays, disappointed hopes, years that will test to the utmost the staunchest scientific spirit.

If we ask young men and women to face such a prospect as this, we must not trade upon their devotion to its joys and disciplines. We must give them honour, freedom, financial security—all the rewards that the quality and value of their work demand. In return they will bring us, in terms of fundamental biological discovery, a recompense that

will be very great. In terms of relief of human and animal distress and suffering, the recompense will scarcely be measurable.

[1] Hobson, A. D., *Parasit.*, **38**, 183 (1948).
[2] Read, C. P., jun., *Rice Institute Pamphlet*, **37**, No. 2 (1950).
[3] Smyth, J. D., *Biol. Rev.*, **22**, 214 (1947).
[4] Wardle, R. A., "The Physiology of Tapeworms". *Manitoba Essays* (Toronto, 1937).
[5] Lwoff, A., *et al.*, "Biochemistry and Physiology of Protozoa", vol. 1 (Academic Press, Inc., New York, 1951).
[6] Lapage, G., *Pub. Imp. Bur. of Agric. Parasit.* (St. Albans, 1935).
[7] Lapage, G., "Nematodes Parasitic in Animals" (Methuen and Co., Ltd., London, 1937).

ADVANCES IN MEDICINE

Annual Review of Medicine

Windsor C. Cutting (editor), Henry W. Newman (associate editor). Vol. 2. Pp. x+485. (Stanford, Calif.: Annual Reviews, Inc., 1951.) 6 dollars.

IN this publication, twenty-six contributors under the editorship of Cutting and Newman review the advances made during the past two or three years in a wide variety of medical topics. There are nineteen sections in the book, the last being an annotated list of such review articles as appeared in the major medical journals during 1950.

The several authors show a considerable diversity of approaches in the presentation of their subjects, and not all are equally successful in securing clarity. The opening chapter, by Burnet, on virus and rickettsial diseases, is an excellent beginning to the book. It is at once readable, informative and well but not excessively documented—there are 136 references in twenty pages of text. Attention has been chiefly confined to advances significant for clinical medicine and public health, and the subjects discussed include the use of antibiotics in rickettsial and virus diseases, recent work on poliomyelitis, influenza, rubella in pregnancy, *Q*-fever, and the Coxsackie viruses.

Grimson and Howe, who review gastro-intestinal tract diseases, approach the subject from a surgeon's point of view. The presentation is far from lucid, however, and apart from the encouraging results attributed to Banthine (β-diethylaminoethylxanthene-9-carboxylate-methobromide) in disorders ranging from peptic ulcer, œsophageal stricture and hiatus hernia to diverticulitis, ulcerative colitis and pancreatitis, there is little major progress recorded.

Diseases of the cardiovascular system are reviewed by Page and Corcoran, and this section is one of the most disappointing in the book. It certainly contains a host of recent references—338 in thirty-one pages of text—but the text to these references is extremely brief and frequently quite uninformative. The authors have assumed a knowledge of cardiovascular research on the part of the reader which few general physicians are likely to possess, and this chapter is consequently far too concentrated and technical for any but a specialist in cardiovascular diseases in search of references. Nesbit and Lapides provide a reasonable and readable evaluation of reports on tuberculosis and other infections of the urinary system, nephrolithiasis and neoplasms of kidney and bladder. An excellent and well-balanced review of the coagulation problem and hæmorrhagic diatheses and disorders of leucocytes is contributed by Finch. The general physician may perhaps feel that this section, too, is somewhat over-documented and technical, but the field covered is small and the references come in a logical sequence. Meiklejohn and Passmore confine their attention, among nutritional topics, to kwashiorkor, famine and ascorbic acid metabolism, and under the heading of allergy Rose has dealt with the relationship of the pituitary adrenal mechanism to hypersensitivity. Both these sections, and particularly the latter, are most informative and clearly written.

The chapters on the reproductive system, the nervous system, psychiatry and the respiratory system are adequate reviews which the authors wisely confine to a few specific topics in each of the fields. The traumatic effects of stress and physical agents are well discussed by Behnke. Garland's section on radiology contains much interesting material but is marred by the fault, common to so many contributors in this work, of quoting too wide a bibliography with the minimum of textual reference. In a chapter on laboratory aids to diagnosis and therapy, Peters reviews only topics in which his own experience has been considerable. They include much research on serum content of precipitable iodine, lipids and proteins, measurement of body-fluid volumes and renal clearances. Scholtz and Williamson stress the growing appreciation of the close relation between skin disease and internal medicine and review progress in fields where this relationship is conspicuous.

Selye contributes an essay on the general adaptation syndrome which provides an admirable summary of his own work and views on this subject. He does not attempt to cover all recent work in this field, and the twenty-two references are all to the author's own publications. Aub and Nathanson summarize the clinical and experimental work done with adrenotropic hormone and cortisone in neoplastic conditions and conclude that these drugs affect the environment of the tumour rather than the growth itself. Kuzell has limited his contribution on diseases of bones and joints to rheumatoid arthritis and gout, and his review of the work on these subjects is most valuable. There is a full discussion of the use of adrenotropic hormone and cortisone in these diseases.

The content of this book may be summarized as a laudable attempt to perform an impossible task.

LIONEL WHITBY

JACOBSON'S ORGAN

Ouvrages sur l'organe voméro-nasal

Par Louis Jacobson. Avec préface et notes par O. C. Hollnagel-Jensen et Dr. Erik Andreasen. Pp. xxxi+175. (Copenhague: Einar Munksgaard, 1948.) 30 kr.

LOUIS LEVIN JACOBSON, having so far escaped the inquisitive attentions of the denigrator, enjoys the unusual distinction of having actually discovered the vomeronasal sense organ of vertebrates with which his name is associated. Its duct, however, the nasopalatine canal or Stensen's foramen incisivum (canalis incisivus), had been seen by Vesalius in the dog and horse, and, apparently, in its vestigial state, in man himself. This Vesalian observation, which is described on p. 54 of the 1543 "Fabrica" and on p. 67 of the 1555 edition, is not correctly quoted in Cuvier's report reprinted in the present volume. Jacobson's organ in its most highly developed condition, as exemplified in some reptiles[1], is in communication with the nasal cavity, and secondarily also with the buccal cavity by the incisive or nasopalatine canal. Jacobson was the first to

establish the latter connexion. The organ itself is represented in the early human fœtus, but later it becomes vestigial, and may be absent in the adult. Jacobson's discovery was first made known by Cuvier in 1811[2] during Jacobson's life-time.

This exhaustive and beautifully produced work by Hollnagel-Jensen and Andreasen, printed in an edition of three hundred numbered copies, includes the following eight sections: (1) Portrait of Jacobson. Preface of 20 pp. describing the main events of his life, and bibliographical details of his unpublished MSS. which the authors succeeded in finding. Apart from the discovery of the vomeronasal organ Jacobson's most important contribution to the literature of comparative anatomy was the demonstration of the existence of a second portal vascular system, the renal portal system, in all classes of vertebrates except mammals. The authors dispose of the claims on behalf of Ruysch and v. Soemmerring to have anticipated Jacobson in the discovery of the vomeronasal sense organ. We learn that Jacobson was not eligible for a chair in the University of Copenhagen in 1815 on the ground that he was "un homme adhérant à la religion mosaïque". (2) French translation of 22 pp. of an undated MS., with notes, presented to the Academy of Science of Denmark on January 4, 1811, which contains a description of a secretory organ in the nose hitherto unrecorded. Three figures are mentioned in the MS. but were not found by the senior author when the text was discovered. The Academy did not publish the paper, which opens with the well-known and impeccable quotation from the Latin edition of Galen—"Quicunque vult operum naturæ esse contemplator, non oportet eum anatomicis libris credere, sed propriis oculis". (3) The only description of the vomeronasal organ published by Jacobson himself was a paper in Danish printed in a Copenhagen veterinary journal in 1813. This paper is not recorded in bibliographies and is practically unknown. In it Jacobson states that he had already sent to the Denmark Academy of Science a complete description of the organ which was not published, but which he now uses and supplements as the basis of the article in the veterinary journal. This paper is also translated into French in 19 pp. of the present work, and its two plates of the horse are reproduced. The animals mainly dealt with are the ox, horse, pig and dog. (4) When Jacobson was in Paris in 1812 he deposited with the Institute of France a memoir on his discovery entitled "Description anatomique d'un organe observé dans les mammifères", which was read on January 13 of that year but not printed. The text of this MS. was recovered by our authors in 1946, but the 12 plates by which it was illustrated could not be found. This was the MS. used by Cuvier in drafting his report of "1811". It is now published in full in 17 pp. (5) Reprint of 8 pp. of Cuvier's report on the preceding MS. dated March 2, 1812, with a collotype reproduction of the first page. The report itself was published contemporaneously in the Annales du Muséum d'Histoire Naturelle, XVIII, "1811". (6) Collotype reproduction of 57 pp. of the whole of the most important MS. which was recovered by the senior author and is described in section 2. (7) Preserved in the archives of the Veterinary Society of Denmark is a packet of unpublished figures inscribed "Jacobson's drawings for his researches on Jacobson's organ". They are apparently not all by Jacobson himself, and the authors reproduce on 25 pp. those which have a particular bearing on the subject. The animals included are monkey, cat, dog, otter, hedgehog, rat, rabbit, hare, little anteater, pig, deer, sheep, ox, musk-deer and horse. (8) Notes and commentary.

Such are the contents of this important and conclusive work. It is no exaggeration to claim that on the subject of which it treats there is no more to be said. The senior author died in 1946. It is to be hoped that the junior author, Dr. Andreasen, will pursue his historical studies on Jacobson, and let us have another memoir of the same class on Jacobson's classic researches on the renal portal system. It is a remunerative subject and needs clarification.

F. J. Cole

[1] Cf. Bellairs and Boyd, *Proc. Zoo. Soc.*, 120 (1950).
[2] So dated, but Cuvier's report was not completed until March 1812.

HUMANISM AND TECHNOLOGY

Man the Maker

A History of Technology and Engineering. By R. J. Forbes. (The Life of Science Library.) Pp. xv+355+41 plates. (London: Constable and Co., Ltd., 1950.) 25*s*. net.

THIS volume is a recent addition to the Life of Science Library and maintains the established tradition of the series by its treatment of the history of technology in relation to its human setting. In his preface, the author claims that in the combined experiments and technical creations of hundreds of generations the figure of humanity rises as clearly in this field as in the fields of literature and art. He continues, "In order to make this clear and to show how deeply such mechanical arts as engineering and technology are embedded in the spiritual life of mankind, we have followed up a few threads of this history from the dawn of human life to the dawn of the Atomic Age. . . . In keeping with the general design of the 'Life of Science Library' we have accordingly restricted ourselves to the story of such essential topics as power resources, transportation and communication, metallurgy, textiles, glass, chemical technology, and some aspects of civil engineering."

The first chapter, "Man and Nature", is important as an introduction to what follows. It is concerned with man's relation to Nature, the difference between discovery and invention, and the widespread diffusion of certain inventions. In the main, the first half of the book is arranged chronologically so that successive chapters deal with "The Dawn of History", "The Great Empires of the Ancient Near East", "Greeks and Romans", "Wardens of the Classical Heritage". The last-named refers to the important part played by the Arabs. The next chapter, "Technology and Theology", covers roughly the same period and describes many developments which paved the way for the birth of the 'New Science' treated in Chapter 7 under the title "New Wine into Old Bottles (1500–1750)". The three remaining chapters relate to steam, the conquest of distance, and steel and electricity. The first is closely associated with the Industrial Revolution and the perfecting of steam power; the new iron metallurgy, textile factories and the rise of a chemical industry are treated in some detail. In Chapter 9 the development of road building, bridges, canals, means of transport on land, sea and in the air, all make interesting reading, and, with modern applications of electricity described in the last chapter of the book, a fitting climax is

reached in the story of man's achievement. The epilogue—"Technology and Progress"—though brief is apt. The limitations of science are recognized, the essential unity of mankind is stressed and the author concludes: "No world can be built on the basis of material progress alone. We must supplement our material gains with a deeper understanding of the mind and spirit. Using the science of matter to implement the science of man is the task of present and future generations."

The numerous plates and illustrations, together with a good bibliography, add to the value of this informative and readable book.

H. D. ANTHONY

PREHISTORIC METALLURGY OF COPPER AND BRONZE

Notes on the Prehistoric Metallurgy of Copper and Bronze in the Old World

By H. H. Coghlan. (Pitt Rivers Museum, University of Oxford. Occasional Papers on Technology, 4.) Pp. 131+16 plates. (Oxford: Pitt Rivers Museum, 1951.) 15*s*.

THOUGH doubtless the last word has not been said on the prehistoric metallurgy of copper and bronze in the Old World, this work by H. H. Coghlan is certainly the most important treatise on the problem that has been published for many a long day. In the Tripos examination at the University of Cambridge the question, "Starting with the appropriate ores, how would Bronze Age man proceed to fashion a palstave?" has once or twice appeared; I venture to think that few of our older archæologists would have been able to obtain an 'alpha plus' on this question, which yet is fundamental to the subject. However, the publication of this book now renders any excuse untenable.

What makes the book authoritative is the fact that Mr. Coghlan had had years of metallurgical experience before he became curator of the Newbury Museum. It is thus written by a man who has knowledge, not by an archæologist who has merely read about smelting. The work opens with chapters on native copper and non-ferrous ores and their discovery in antiquity. Chapter 3 deals with the sequence of the metals and the results of analysis. There follow chapters on the mechanical properties of copper and bronze and the different methods of casting. An important chapter describes the various implements known to have been used by the prehistoric metallurgist, such as tongs, drills, files, etc. Later in the book the methods of soldering and welding are outlined. The work concludes with several chapters on the results of metallurgical examinations of a number of ancient examples of the metal-worker's art.

Mr. Coghlan does not think it possible that Bronze Age man could have obtained his copper from the abundant copper sulphide ores. Here one may perhaps hesitate to agree. Bronze Age man was a skilled metallurgist. Everything seems to point to the fact that he was perfectly aware of what he was doing. It was not all mere chance. The speed with which the knowledge spread that copper with 10 per cent tin and without other ingredients was the most suitable alloy is impressive. It argues that the development of metal-working took place in a limited geographical area, that the men themselves were consciously experimenting and that they knew what they were trying to do. Sulphide ores require the prior process of roasting before reduction; but the abundance of these ores would surely have interested the Bronze Age metal workers, and they were quite capable of finding out how to utilize them to obtain the needed pure copper.

M. C. BURKITT

BRITISH VARIETIES OF CEREALS

Cereal Varieties in Great Britain

By R. A. Peachey. Pp. 202. (London: Crosby Lockwood and Son, Ltd., 1951.) 21*s*. net.

DURING the past fifty years there has been an endless interest in the subject of cereal varieties, largely due to the increased demand for agricultural produce of definite quality for specific purposes, such as is required in the processes of baking and malting. With the great increase in agricultural production in Great Britain and indeed throughout the world since 1939, the interest in cereals has been accentuated still more. This is partly due to differences in their yielding capacity; but recent advances in the mechanization of harvest operations have shown the greater suitability of some varieties of cereals to the changes required by this development. In "Cereal Varieties in Great Britain", the author has brought together in a most available manner the information of a general nature regarding the principal varieties of wheat, oats and barley in cultivation throughout this country.

This book is in reality a photographic record of the varieties of cereals grown in Great Britain at the present time. It is obvious on looking at the illustrations that each specimen ear has been selected with great care to show so far as possible the distinguishing botanical features of each variety. On the whole the illustrations are very faithful to the living specimens. The book illustrates and describes sixty-seven varieties of wheat, sixty-one varieties of oats and eighteen varieties of barley—that is to say, nearly all the varieties which could possibly be found growing as field-crops in the British Isles. The selection of the varieties is on a wide scale and not confined to those varieties the superiority of which in some or other direction has been demonstrated by authoritative field trials and qualitative determinations.

Particular attention has been paid to the origin of a variety. Wherever possible the parentage of the variety, and the breeder or introducer, as well as the date of introduction into commerce, are given.

The book is of outstanding importance to all concerned with the cultivation and identification of cereals. With the aid of the descriptions of the young plant, ear, glume, grain and straw and the series of exceptionally good illustrations, the identification of any unknown cereal should offer few difficulties. Methods of harvesting and the factors which are important in considering the suitability of varieties to certain conditions of soil, climate, etc., are also dealt with. This part should appeal to the practical man. Seedsmen and crop inspectors especially will find it a most useful guide and reference book.

J. S. L. WALDIE

The Heaviside Centenary Volume

Pp. v+98+6 plates. (London: Institution of Electrical Engineers, 1950.) 10*s.*; 4*s.* to members.

THIS well-produced and attractive volume is a record of the special meeting of the Institution of Electrical Engineers, held on May 18, 1950, to commemorate the centenary of the birth of Oliver Heaviside (see *Nature*, 165, 991; 1950). It contains the texts of the tributes paid to his memory by Prof. E. B. Moullin, president of the Institution, Sir Robert Robinson, president of the Royal Society, Sir Edward Appleton, Dr. M. J. H. Ponte, representing the Société Française des Électriciens and also the Société des Radioélectriciens, Sir Archibald Gill, Dr. O. E. Buckley, president of the Bell Telephone Laboratories, Prof. Harold Jeffreys, Sir Edmund Whittaker and Dr. G. F. C. Searle.

In addition, there are the following papers: "Oliver Heaviside—The Man", by Sir George Lee; "Some Unpublished Notes of Oliver Heaviside", by H. J. Josephs; "An Appreciation of Heaviside's Contribution to Electromagnetic Theory", by Prof. Willis Jackson; "Heaviside's Operational Calculus", by Prof. Balth van der Pol; "Fifty Years' Development in Telephone and Telegraph Transmission in relation to the Work of Heaviside", by Dr. W. G. Radley; "Heaviside's Pure Mathematics", by Prof. Harold Jeffreys; and "Oliver Heaviside—A Personal Sketch", by Dr. G. F. C. Searle. These papers bring to light many facts about Heaviside's character and his work which had been obscured by the seclusion in which he lived and by the mode of presentation and inherent difficulty of many of his published papers. The most important section of the book is the impressive reconstruction by Mr. Josephs of portions of Heaviside's unpublished work under the following five headings: infinite integrals, 'physical' mathematics, electric circuit theory, electromagnetic theory and unified field theory. It is to be hoped that the contents of other portions of the manuscripts now in the possession of the Institution will also be published in due course.

The Institution of Electrical Engineers is to be congratulated on the preparation of a magnificent tribute to one of the most famous of its honorary members and to the man whom it selected to be the first recipient of the Faraday Medal.

The World of Science

By Dr. F. Sherwood Taylor. Second edition. Pp. xviii+1064+48 plates. (London: William Heinemann, Ltd., 1950.) 21*s.* net.

THIS encyclopædic volume can be confidently recommended to the man of science and layman alike, both for general reading and as a reference book. I have found the first edition, published in 1936, to be a most valuable source book and its index a reliable guide. This second edition should prove equally valuable and interesting reading, for it is, in fact, largely a reprint of the first (bearing the same page numbers), but with a number of pages inserted at various points to carry the new material. Most of the remarkable advances that have been made since the first edition are covered; they include atomic energy, radar, gas turbines, new elements, recent astronomical theories, new drugs, and modern theories of the origin of man.

The printing, especially the line blocks, is not as sharp as it might be, doubtless owing to the method of reproduction from the first edition which has been employed. On the other hand, this slight shortcoming is offset by the remarkably low price of 21*s.* for these days (which might be compared with the 8*s.* 6*d.* for the first edition which had almost the same number of pages).

The last chapter "Looking Ahead" differs only by the addition of a sentence or two from that written fourteen years ago; surely the author's publishers will encourage him before an equally long period passes to produce a third edition which will not have to be so closely tied to the original text. H. R. Lang

Mechanics

A Text-Book for Engineers. By James E. Boyd and Prof. Percy W. Ott. Third edition. Pp. xii+422. (London: McGraw-Hill Publishing Co., Ltd., 1950.) 38*s.* 6*d.*

IT is always a pleasure in welcoming a book which bears the stamp of thoroughness, and this book is an example of a carefully thought-out plan to put clearly before students the fundamentals of the subject. The execution of this plan has resulted in a really sound book, now in an enlarged third edition, which cannot fail to assist the student. The aim is to emphasize with illustrative examples the fundamental principles, and to encourage the student to use logical thinking and suitable mathematical methods in solving problems based on the principles. Greater stress is placed on the application of the principles to problems, especially numerical ones, rather than on the mathematical derivation of the principles or the relationships which they bear to one another.

The authors have evidently spared no time or trouble in an endeavour to make things clear, and they have eminently succeeded. The short space devoted to the principle of virtual work gives the clearest exposition of this very useful method seen by the reviewer in a book of this standard. The same thoroughness which pervades the text is repeated in the diagrams, which are excellently done.

Progress in Biophysics and Biophysical Chemistry

Editors: Dr. J. A. V. Butler and Prof. J. T. Randall. (Progress Series.) Pp. viii+279. (London: Butterworth-Springer, Ltd.; New York: Academic Press, Inc., 1950.) 50*s.*

THIS book is the first of a new series which will present at intervals review articles of selected topics in biophysical research. Biophysics is a borderline subject which is difficult to define precisely. Interest in recent years has perhaps centred more on the structure of cells and tissues than on the physics of the mode of operation of organs. However, the nine contributions to this first volume have been well chosen and cover a wide field.

The reviews are in general well documented and provide a useful starting-point for further reading. They are written in a critical vein and give expression to the opinions of the various authors. They combine, therefore, the personal interest of an essay with the substance of a progress report. The aspects covered include the properties of solutions of large molecules, fundamental molecular structures in biological systems, X-ray and light scattering by protein solutions, bioelectric potentials, phase-contrast microscopy, the theory of local refractometry, the assay of biological materials by soft X-ray absorption, the tolerance of man for radioactive isotopes and the mechanical properties of muscles and fibres.

The production of the book is of a high standard.

D. P. Riley

NATURAL AND ARTIFICIAL PRODUCTION OF ATMOSPHERIC PRECIPITATION

A DISCUSSION on the "Natural and Artificial Production of Atmospheric Precipitation" was held on August 10 at Edinburgh as part of the programme of Section A (Mathematics and Physics) of the British Association. The session was opened by the president of the Association, H.R.H. the Duke of Edinburgh.

B. J. Mason (Imperial College of Science and Technology, London) read the first paper and began by describing the mechanisms responsible for the release of natural precipitation, emphasizing that an understanding of the fundamental physical processes is essential if artificial rain-making experiments are to be carried out intelligently and their results assessed in a realistic manner. He said that the collision and the resultant coalescence of droplets having differential rates of fall, while capable of producing only drizzle or light rain from layer clouds, can release a heavy shower from a deep, vigorous, cumulus cloud by initiating a water-drop chain reaction. This process will be favoured in tropical regions, particularly in unstable maritime air-masses, where sea-spray may supply the larger droplets required to start the coagulation process. In temperate latitudes and well inland, showers are more likely to be released by the action of ice crystals. Growing initially by diffusion, the crystals afterwards sweep up supercooled cloud droplets to form pellets of soft hail, which may melt to form raindrops. Rain falling from deep layer-clouds generally originates from melting snowflakes, which are formed by the coalescence of ice crystals. In cumulus clouds containing strong updraughts and high concentrations of liquid water, a water-drop chain reaction may be initiated by the shedding of large droplets from hailstones which amass supercooled water at a rate greater than it can be frozen.

In describing and assessing the results of artificial rain-making experiments, which attempt to induce precipitation by 'seeding' suitable clouds with pellets of dry ice, crystals of silver iodide or small water-droplets, Mr. Mason said that there has been a distinct tendency to draw spectacular conclusions on the basis of too few observations, and that too little attention has been paid to the need for adequate control experiments. However, many cases have been reported of rain falling from clouds a few minutes after seeding. Although in any particular case it is not possible to ascertain that this would not have happened without seeding, in many careful dry-ice experiments carried out in Australia by the Council for Scientific and Industrial Research (now the Commonwealth Scientific and Industrial Research Organization), under the direction of Dr. E. G. Bowen, rain has been observed to fall from seeded cumulus clouds, while similar clouds in the immediate vicinity produced no precipitation. Since, for a high probability of success in the dry-ice experiments, the cloud top must be colder than − 7° C. and rain is likely to fall naturally if it is colder than − 12° C., there is only a narrow range of conditions in which seeding with dry ice can anticipate natural events. The position is still more unfavourable in the case of silver iodide, which suffers the additional disadvantage that it becomes inactive as an ice nucleus when exposed to strong sunlight for about one hour. Calculations indicate that spraying small water-droplets into the base of the cloud should be a more efficient method of releasing showers from warm cumuli, and the results of recent experiments in Australia are encouraging.

The introduction of dry ice into supercooled layer clouds tends to produce 'over-seeding' and therefore to inhibit precipitation. This danger is reduced by the dissemination of silver iodide from the ground; this method is being used extensively in the United States, but an accurate assessment of the results will be possible only after extended trials in many different regions, comparing the precipitation on a statistical basis with that produced naturally in corresponding control areas. Generally layer clouds will produce little precipitation unless they possess considerable depth, in which case their tops may often be sufficiently cold for precipitation to be released naturally.

Mr. Mason said that there is little doubt that precipitation may be released by seeding techniques. The important questions are how much can be so released which would not fall naturally, and whether the time of release and hence its distribution can be altered. It is possible that, by seeding, the onset of precipitation from a growing cumulus may be advanced by a few minutes, and from frontal cloud systems by perhaps a few hours. This might be of importance in increasing the rainfall in a given area; but judging the optimum time for seeding would, in most cases, be very difficult. It seems unlikely that the rainfall pattern over large areas can be altered materially by cloud seeding, although local modifications may be effected.

It was suggested by Mr. Mason that perhaps the greatest value of rain-making experiments is to be found in the impetus they have given to fundamental research in the physics of clouds and precipitation; they should be continued as scientific experiments in close collaboration with theoretical and laboratory work on the fundamental physical problems, for only in this way can their potential economic value be satisfactorily assessed.

F. H. Ludlam (Imperial College of Science and Technology, London) emphasized that the time-scale of precipitation processes is controlled mainly by the macroscopic features of cloud development, and showed by time-lapse photographs of cumulus clouds that the life-history of a particular mass of cloudy air may be completed in a few minutes. He went on to discuss quantitatively the formation of raindrops and hailstones in shower clouds, tracing the growth of these elements by coagulation in relation to the elapsed time and their height above the cloud base. His calculations show that a droplet of sea-spray of radius about 30 μ is capable of releasing a shower via a water-drop chain reaction in a warm cumulus cloud having a strong updraught; alternatively, this process can be started by a wet hailstone in the manner described by Mr. Mason.

It was Mr. Ludlam's opinion that, even in temperate latitudes, rain is released from shower clouds without the aid of ice crystals; but more critical observations are needed. He also discussed the possibilities of inducing and inhibiting showers by seeding techniques, pointing out that seeding can be used as a tracer in studying the further development of a cloud. For

this reason, and also because he was more optimistic about their potential economic value than other speakers, he hoped that such experiments would be conducted on an increasing scale in the British Isles.

In a paper entitled "Radar Echoes from Precipitation", R. F. Jones (Meteorological Office) pointed out that normal radar equipments working on wavelengths of 3 or 10 cm. can, at ranges greater than ten miles, detect only that part of the cloud in which there are either raindrops, ice crystals exceeding 1·5 mm. diameter, aggregates of ice crystals or ice crystals with a wet surface. He described some results obtained with the radar equipment at East Hill (near Dunstable) which has both position-plan indicators and range-height indicators to give a three-dimensional picture of the echoes received from precipitating clouds. Different weather types are associated with markedly different radar responses, a fact which was clearly illustrated by photographs of the echoes obtained from cloud systems associated with a warm front, a cold front and an occlusion, all of which were of very different character from those obtained from shower clouds. The echoes from layer clouds are generally of limited vertical extent and contain a narrow band of great intensity (the 'bright band'), while those from cumulo-nimbus appear as narrow vertical columns attaining heights of perhaps 40,000 ft.

Mr. Jones went on to relate the appearance of the echoes, the rate of ascent of their tops and the temperatures of their summits as measured by aircraft, to the mechanisms of precipitation release. In particular, he associated the appearance of the 'bright band' in layer clouds with the melting of snowflakes, and the echoes from cumulo-nimbus (which show no 'bright band') with the existence of large water-droplets, often supercooled, which must have formed by the coalescence process. He reported on some aircraft observations which appear to support these interpretations.

In a paper read by H. P. Palmer, Dr. A. W. Brewer (Oxford) stated that in Great Britain nearly all rain originates from ice crystals, and because of this it is a reliable rule in weather forecasting that cumulus clouds will not give showers until the temperature of their summits falls below − 10° C. As first suggested by Bergeron, an ice crystal will grow rapidly in a supercooled water cloud ; but it is important to consider the origin of these crystals. Suitable ice-forming nuclei are found in the atmosphere ; but they are comparatively rare. Their concentration has been measured by Findeisen *et al.* in Prague, and also in Oxford, by the cooling of air by expansion in Wilson cloud chambers. In the relatively polluted air of these cities the ice nuclei were present in concentrations of only about 1 per m.^{3} at − 10° C. Dr. Brewer suggested that ice crystals must multiply during their growth by sublimation since it is not until much lower temperatures than − 10° C. are reached that the ice-forming nuclei are sufficiently numerous to account for all the raindrops which are produced. He reported that ice crystals which are growing rapidly and have dendritic structures release very small splinters of ice. Thus, although only a very few ice crystals may appear originally in a supercooled cloud at − 10° C., they will grow rapidly in a form liable to fracture ; several splinters may form at each fracture, and themselves act as ice nuclei. In this way, a sufficient number of ice crystals may be formed to account for the number of raindrops reaching the ground.

I. C. Browne (Cambridge) described his use of a radar set with a vertical beam and range-amplitude display to study precipitating clouds, in conjunction with observations of the mass and electrical charge of raindrops and the electric field at the ground. He has made a particular study of the variations of echo intensity with height in order to determine the mass and growth-rate of the precipitation elements. In particular, thunderstorms sometimes show a striking increase of echo intensity with decreasing height in a region beneath the freezing-level, which affords some evidence for the growth of drops by coalescence and their multiplication by a chain reaction. The observations yield a value for the updraught velocity in the chain-reaction region. In warm-front rain the echo intensity indicates that at about 1 km. above the melting-level ice crystals are growing at a rate of about 150 μgm./km. Calculation indicates that they could grow at only 50 μgm./km. by sublimation, the inference being that they were growing at about 100 μgm./km. by accretion. The observations also indicate that near the 0° C. level each snowflake, on the average, coagulates with another.

B. J. Mason

SEED PATHOLOGY*

By Dr. MARY NOBLE
Department of Agriculture for Scotland

Agricultural and Horticultural Aspects

EVEN the earliest agriculturists realized the general desirability of using good seed ; but it is very surprising that to-day so little attention is paid to the presence of disease in what is otherwise regarded as 'good' seed. I refer in this respect to true seed in the botanical sense, the health of other planting-stock having been greatly improved recently owing to certification schemes covering potatoes, soft fruits, etc. This is probably because most seed-transmitted parasites do not have any immediate effect upon germination ; they do not kill the seed outright but multiply upon the emerging seedling, which often then succumbs to the attack ; or, as in the case of loose smut of barley, the parasite may pass most of its life-cycle as a symbiont. Such seed, if tested by orthodox methods, is classed as 'good seed' but is, in fact, responsible for considerable loss of crops not only in Great Britain but also the rest of the world. To take, as a case in point, an example from one of our most familiar crops—the turnip. Dry rot of turnip caused by *Phoma lingam* has been known for very many years ; but although the farmer has known this disease as a rot of the root, the growers of swede and turnip seed only recognized it comparatively recently. Swede roots are replanted for seed-production in the second year, and it was found that the base of the shoot was often attacked by the disease known as 'canker'. The important point is that it was not until 1930 that this 'canker' was proved to be merely 'dry rot' in another form ; and what was even more important, that the fungus also infects the seed heads, the pods and even the seed itself but without causing reduction in germination. Until this point was properly understood, turnip and swede seed samples were frequently severely infected by dry rot, because although the seed grower was

* Substance of a paper read on August 13 before Section K (Botany) of the British Association meeting at Edinburgh.

careful to select only the finest roots for propagation he very often planted them in soil which he proved to be suitable for the purpose but which had also thereby become infected with the fungus. The disease is soil-borne as well as seed-borne, so that until recently the importance of seed-borne infection was not fully realized, and even yet it is frequently overlooked that soil infection may have arisen from seed. Some years ago observations made at East Craigs showed that as little as 2 per cent infection of the seed could lead to considerable loss of crop and that this amount of infection is still quite common.

This is not surprising when the method of growing the crop is considered. The seed is sown about ten times more thickly than the resulting crop and infection is disseminated throughout the field. At the time of 'thinning', the rejected plants are not removed but left lying in close proximity to those which remain, so that the risk of infection is not reduced at thinning time but multiplied tenfold. This principle applies to very many similar seed-borne diseases. Again, if seed is sown thickly to make up for low germination the risk of infection is correspondingly increased, as in this disease the fungus does not die before the seed.

Dry rot infection can be very well controlled in the seed by treatment with hot water, and in the north of England this is done as part of the National Agricultural Advisory Service. Generally, however, swede and turnip seeds are sown without any treatment, although even dusting with a mercurial fungicide greatly reduces infection; and from this disease alone the crop loss is considerable.

Again, infection sown with the seed of one crop may remain in the soil to attack a later one. For example, another brassica crop following a swede crop which had dry rot may become in turn infected. In 1948 the ubiquitous fungal parasite *Sclerotinia sclerotiorum* was found carried as a sclerotium in turnip seed. This provided the source for soil infection capable of attacking artichoke, carrot, etc. Blind seed disease of rye-grass presents quite a different case. This disease, caused by one of the Sclerotiniaceæ, was not recognized in Britain until some ten years ago, although rye-grass was for a very long time the only British cultivated grass and indeed the only one of which the seed could be purchased for sowing. The causal fungus, the fructification of which arises from the seed, is very tiny and insignificant, and it is possible that this disease was present much earlier but unrecognized; on the other hand, certain changes had occurred in the rye-grass seed-growing industry which may at least have led to its increase.

One change was the concentration of seed-growing in the areas where the best pastures were found in Britain (Kent, Ayrshire, Aberdeenshire) and, overseas, in New Zealand. This arose from the fact that farmers could not be sure of getting seed of the best pasture strains anywhere else, seed certification schemes being a very recent development. It does not follow that seed production requires the same ecological conditions as pasture development, and in this case the disease is most severe where cool moist weather conditions prevail.

Another change which was more important from the seed pathology point of view was the introduction of improved, leafy strains of rye-grass in Britain as well as in New Zealand. These strains comprised much more uniform populations than the old 'commercial' strains and came into flower much more synchronously than the latter. Thus in adverse weather conditions the damage was greater. Again, these new improved strains have proved genetically to be more susceptible to the fungus and some at least are now being re-selected with reference to this factor. Trials are also in progress with growing the seed in suitable 'seed' areas as against the good pasture areas.

In horticulture the problem of seed health is studied even less than in agriculture. For example, all the sugar beet seed now sown in Britain is disinfected chiefly against the black leg organism (*Phoma betæ*); but very few market gardeners treat red beet seed although it is quite as common as sugar beet.

Dwarf beans, especially of the variety 'Canadian Wonder', are often infected with halo blight, a bacterial disease, and no great effort seems to be made in Britain to avoid the disease. In New South Wales, an inspection scheme ensures the health of dwarf bean seed.

Seed Pathology and Seed Testing

The practice of seed testing or seed analysis is, of course, intimately bound up with seed pathology, and in this Great Britain has from the beginning lagged behind the Continent and the United States—at least in officially implementing the recommendations of the few who pointed the way.

Thus the first official seed-testing station in the world was established in Saxony in 1869. In 1885 a writer in the *Transactions of the Highland and Agricultural Society* pleaded that Scotland might also set up such stations, especially as the Royal Agricultural Society of England had been testing seed for its members since 1871 and had in 1882 laid down standards for purity and germination. But although a departmental committee set up to examine farm seeds had recommended in 1900 the establishment of a station, nothing was done as it was officially considered that the public would not take advantage of such facilities, or perhaps the reason given by R. H. Elliot, addressing the British Association in 1904, was more accurate: "The bewildering variety of our national affairs no doubt leaves little time for the Government to notice the needs of the biggest and most important industry of the kingdom", a reproach which is fortunately not true to-day.

But seed pathology was even at this time being studied elsewhere in the world. At Iowa the work was begun by Bessey, and in 1886 a State College bulletin was issued on the results of germination tests with notes on the fungi. It is surely not without significance, considering the leading part still taken by Iowa in seed testing and seed pathology, that from the first these two studies were so closely allied in that State. Every mycologist knows the initials which represent the authorities for the fungus name *Helminthosporium sativum*, P. K. and B., but how many know that Pammel was a botanist on the staff of the Station, and that Charlotte King, at that time assistant botanist, became an official seed analyst of Iowa? Nevertheless, this fungus, so commonly seed-borne in American crops, was not named until 1910, when these authors published a bulletin on *Helminthosporium* spp. on barley, including *H. gramineum* and *sativum*, which they described as seed-borne.

For very many years the leading work in seed pathology was carried out in the United States and

in Holland, where Dr. Lucie Doyer was the pathologist at the State Seed Testing Station at Wageningen, a centre which has always been noted for generously helping and co-operating with others.

In Britain very little attention indeed was paid to seed testing in relation to pathology, and this in spite of the repeated warnings even from the time of Jethro Tull: "In some sorts of seeds the goodness cannot be known by the eye". Sir John Sinclair said in 1782: "So far as oats are concerned—the clearest and best-looking oats when sown often produce the worst crop". But at last in 1920 the first and only British Seeds Act was passed, giving the farmer much greater protection and security in purchasing seeds than ever before. But even then, only certain crops were safeguarded; the Act does not apply to all seeds. Not that this was required where honest seedsmen were concerned, and there were several excellent seed firms all over the country whose names to-day still are sufficient guarantee; but there always have been less scrupulous merchants and individuals whose activities caused severe loss to farmers and gardeners.

However, even the most skilled and honest seedsman could not be blamed for selling seed carrying infection which no one knew how to detect. In many cases, indeed, it was not even known that the seed was infected at all, as has been shown in the case of dry rot of swedes. Surveys of the various seed crops would have given valuable information; but plant pathological survey work of this nature in Britain was greatly restricted because of lack of staff and facilities.

But pioneer survey work was done by Dillon, Weston and Brett on cereal seed in England, by Hickman on pea seed, when he found twenty-six out of twenty-nine English-grown samples to be infected with pod spot; the Ministry of Agriculture's Plant Pathology Laboratory continues to examine seed for export, and in Northern Ireland Prof. A. E. Muskett and his collaborators are doing valuable work. In Scotland the work begun by Mrs. Alcock, who published in 1931 an annotated list of seed-borne diseases, has been to some extent continued.

In Canada, however, such a survey began in 1937, where, to quote Craigie: "Seed-borne diseases exact a heavy annual toll from every important farm crop in this country".

As already noted, the United States and Holland were among the first countries seriously to study the problem.

The development of techniques by which these diseases could be detected is in itself a fascinating study which can only now be briefly outlined.

There are two main lines of approach: (1) to reveal the total number of seeds in any given sample which are harbouring an organism—fungal, bacterial, animal or virus, saprophytic or parasitic; (2) to assess the likelihood of specific infection giving rise to disease in the crop.

The first approach is appropriate when surveying and also when examining seed for export, and the second when examining seed for such purposes as the operation of inspection schemes where specific diseases require to be detected. With any one sample of seed the result obtained is greatly affected by the method used. In a recent paper from Canada, Wallen and Skolko state: "Standardization of seed testing methods in respect to germination and purity has been attained through the Association of Official Seed Analysts of North America and, at the international level, through the International Seed Testing Association. Much less agreement exists in the matter of testing seed for the presence of pathogenic organisms. The reason for this lack of uniformity in methods of disease diagnosis may be attributed primarily to the development by individual laboratories of seed testing methods especially suitable to their own requirements, facilities and personnel. Standardization has undoubtedly also been hampered by the fact that comparatively little is known of the seed-borne phases of many of these organisms, the failure to develop satisfactory methods of detection for seed-borne pathogens, and the emphasis on the empirical application of seed treating procedures for their control, with the consequent neglect of fundamental information as to how the seed treatment is operative. As a consequence of the differences in seed testing methods, misunderstandings are inevitable and proper interpretation of reports is not possible."

In this paper the authors were dealing with the 'Ulster', 'Ottawa' and 'New Zealand' methods—variations in the agar plate method of testing flax seed. The seed to be examined is, in the Ulster method, plated directly on to malt agar without prior surface disinfection or washing; slow-growing fungi are soon overgrown if the seed is heavily contaminated. In the Canadian method a disinfectant is used, and this makes the separation of the fungal flora easier. But in both methods the seed germinates, and in so doing may lift the infected cotyledons or even the testa above the surface of the agar. In the New Zealand method this difficulty is overcome by using deep agar and submerging the seeds, which are first washed in running water. More recently, Hagborg and Warren in Winnipeg have very ingeniously used 2,4-*D* to inhibit germination of the seed, simply adding the 2,4-*D* to the agar. Wallen and Skolko draw this very reasonable conclusion from their study: it is not the purpose of this paper to suggest which of the three methods should be adopted in seed-testing procedure but rather to indicate the necessity of defining the method on which a given report is based.

It might be further mentioned that even the disinfectant used for surface sterilizing can alter results. Thus in examining wheat seed for *Septoria nodorum* by plating, I found that 'Chloros', a chlorine type of dairy disinfectant, was less drastic in killing fungi than methylated spirit, but controlled bacterial contaminants more efficiently. This type of disinfectant has also the added advantage that the seed need not be washed again before plating—a process in which certain fungi (for example, those with pycnidospores ?) may be spread from an infected to a healthy seed. These methods, however, do not differentiate between saprophytes and parasites. It is often easier to grow the seed in such conditions as are known to induce the parasitic fungi to attack the developing seedling, identification then depending on the symptoms produced. Thus in Sweden *Fusarium* infection in rye is determined by sowing seed under ground brickstone, which induces characteristic twisting of the shots. A variation of this method using sterilized sand has proved successful at East Craigs for testing oats for *Helminthosporium* as well as *Fusarium* spp. Some samples with 'official' germination capacity of around 95 per cent were found by this method to be perhaps 20–30 per cent infected, so that their value to the grower was reduced accordingly. In the case of oats infected with these

diseases, the official figure is generally too favourable; but in others the reverse is true. *Ascochyta imperfecta*, the cause of black stem disease, is very common in trefoil samples and spreads very rapidly from seed to seed under the conditions of the official test in incubators, so that infection appears much higher than if the seed is sown in soil. This fungus illustrates another point: that certain seed-borne diseases are already well known to skilled analysts because of their effect on the appearance of the seed: trefoil seed severely infected by *Ascochyta imperfecta* is dark brown in colour and rather flat, while more superficial infection appears as thin black lines, which are, in fact, thick-walled hyphæ, visible on the seed to the naked eye. The analysts at East Craigs recognized these marks as indications of poor quality seed before we proved them to be specific fungal infection. There is no doubt that similar investigational and survey work on seed crops as well as seed after harvesting would yield most interesting results. There is now a very large industry in crop protectants, including seed disinfectants, but more attention should be paid to the production of healthy, vigorous seed. In this respect chemistry has outrun biology.

International Aspects of the Problem

These problems are not confined to Britain, for this country is involved in the international trade in seeds. In 1950 Britain imported seeds to the value of £4½ million and her exports were more than £2½ million. It may, of course, be argued that so far as seed-borne disease is concerned we must already have spread them around and received every possible foreign trouble and that it is now too late to shut the stable door. There are, however, still some diseases which might be imported here; bacterial blight of peas is one, and as it is most severe where frost pockets are found we might expect it to do great harm in Scotland to our expanding industry of growing peas for canning. Then a recent attempt to grow soya beans in Scotland was unsuccessful owing, at least in part, to seed-borne bacterial blight. Our seed came from Sweden, where the disease was unknown until a few years ago, when it was imported with seed of new American varieties.

To endorse this aspect of the problem, I should like to quote again from a paper read at the British Association at Cambridge in 1904. The speaker was R. H. Elliott, of Clifton Park, Kelso, to whom Stapledon has referred as the father of grassland husbandry. In his paper he appealed for seed testing to be begun officially in Great Britain. He died in 1914, the year that the Department of Agriculture for Scotland began the first advisory, as against statutory, seed testing. But he also asked that our farmers should be protected against the introduction of diseased seed from abroad. Now, almost fifty years after, it seems that there is hope that this also will be done.

Last year the Government issued the report of the committee set up to investigate the qualitative control of seeds. As a member of this committee recently said: "In the early stages of the development of seed testing practice, the emphasis appears to have been upon providing a ready means of assessing seed values, largely for the purpose of facilitating trade in seeds, without particular thought as to the value of the data to the grower".

The committee in its report has fully met this point and has further recommended, so far as health is concerned: (1) there should be an early extension of health surveys of home-grown and imported seeds; (2) there should be further research into methods of detecting seed-borne organisms, and to find suitable technique whereby seed samples can be examined speedily and accurately for the presence of diseases or pests; (3) seed-testing practice should be extended to cover health; (4) seed certification schemes should include inspection for disease.

Further, there should be close collaboration between the seed-testing stations and the plant pathology services and continued close liaison with the International Seed Testing Association.

The International Seed Testing Association, which had its first post-war meeting in Washington in 1950, has a Pathology Committee which will undoubtedly welcome this approach. Then in spring 1951 Great Britain signed the convention of the European Plant Protection Organization, under which we now commit ourselves to survey our crops for the presence of certain pests and diseases with the view of ensuring, in collaboration with the other subscribing countries, that these are not further spread abroad. One of the means of dissemination to which attention will be paid will undoubtedly be the seed.

In conclusion, therefore, the outlook for the further study of seed pathology in Great Britain and abroad is distinctly promising.

MINERALS AND MAGMAS: STUDIES AT HIGH TEMPERATURES AND PRESSURES*

By E. D. LACY

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A CARDINAL aim of the petrologist must be to explain the natural history of the rocks of the earth's crust in physico-chemical terms. To that end investigation of equilibria in dry silicate melts has been pursued for many years, with fruitful results, notably in the Geophysical Laboratory, Washington. Although studies on hydrous silicate systems were commenced there as long ago as 1914, their range has been limited until comparatively recently.

Water is an important component of magmas and of many minerals, and its presence in magmas is significant in several respects. The viscosity of the fluid is diminished and crystallization temperatures are lowered. Hydrous minerals such as amphibole or mica may be precipitated, though it does not necessarily follow that they will. At a late stage in the cooling a fluid rich in water may remain, capable of profoundly modifying either the early crystallized material or neighbouring rocks, or of transporting substances, such as sulphides, to a locality where lower temperature brings about their precipitation. When magmas reach the open air, the water they contain is largely fugitive, but when they cool at depth the water may be retained, at least for a time, because of the load of superincumbent rocks.

The part played by water in the metamorphic rocks is less well understood. Here the mineralogy and texture now displayed is due to recrystallization, which took place in the solid. Complex conditions attend such change and it is certain that water in

* Substance of a paper read on August 14 before Section C (Geology) of the British Association meeting at Edinburgh.

trace amount has a considerable influence in promoting the breakdown of unstable minerals and the simultaneous growth of stable ones. When available in larger amounts, water may enter into the composition of metamorphic minerals such as chloritoid or staurolite. Water is undoubtedly instrumental in promoting the transfer of material both by processes of ionic diffusion and of solution. In metamorphism the rock load tends to promote closure of the system with respect to water.

Fundamental to all understanding of silicate crystallization phenomena, both in melts and in solid media, is a knowledge of phase stability relations. The range of temperature/pressure conditions to be covered is wide. Magmas are known to reach temperatures up to 1,185° C. Burial in the earth's crust involves a hydrostatic load increasing at the rate of 400 atmospheres per mile; hence experimental work faces formidable difficulties. A considerable number of workers, many in American laboratories, have contributed in this field. The designs for the necessary specialized apparatus can be classified broadly under three headings.

(1) *Closed bombs.* The material to be investigated is placed in a thick-walled vessel along with a calculated amount of water. The sample may be protected from contamination by the bomb wall by being placed in a crucible or by lining the bomb with noble metal. As in all similar work, it is desirable to bring about the reduction to room temperature very rapidly, in order to preserve the high-temperature products without change. This is done by quenching the bomb in cold water. Temperatures as high as 700° C. may be reached, but the pressure range is limited. The bomb typically is of about 100 c.c. capacity. Morey, Ingerson and Grunner are among the workers who have used this method, which is not preferred for precise work as the pressure developed on heating is known only approximately by computation, and leakage readily leads to inaccuracy.

(2) *Controlled autoclaves and bombs.* In this category come pressure vessels, varying largely in internal capacity, provided with pipe connexions to control valves and to gauges for measuring the pressure. The pressure may be generated solely by water placed in the bomb before sealing, or a high-pressure pump may be employed to inject water into the system as required. The vessel may be lined or the sample placed in a crucible as before. Variations of such apparatus have been designed which permit the sample to be refluxed or which expose the sample to percolation under pressure. The working space within apparatus of this type tends to diminish with increase in the severity of the pressure/temperature conditions.

The apparatus used by Bowen and Tuttle has yielded results of outstanding importance and is capable of withstanding an internal pressure of 1,000 atmospheres at a temperature of 1,000° C. The bomb is of very small capacity, and is rapidly cooled at the end of an experiment by using a retractable furnace and a water spray.

(3) *Apparatus using capsules.* In all the designs mentioned above, the pressure medium is water, a constituent of the system being investigated, which is thus an open one.

Goranson developed a technique for enclosing the solid sample and the volatile component in a thin platinum capsule. The system was thus completely protected from contamination, and furthermore several samples of varying composition could be dealt with at once. The capsules were heated in a furnace which was itself enclosed inside a pressure bomb, which latter was water-cooled. The pressure medium was carbon dioxide, supplied by an external pump. Under pressure, the sealed capsules collapsed until the pressure of water vapour within equalled the carbon dioxide pressure. With this apparatus runs were made at 1,200° C. under 4,000 atmospheres pressure. The drawbacks lay in the great cost and complexity of the apparatus and the apparently rather low rate of cooling.

A technique embodying new features has been developed in the Department of Geology, University of Birmingham. A sample is taken which may consist either of an artificial mixture, or of a cylinder of rock up to nearly $\frac{1}{4}$ in. in diameter and large enough to make it possible to cut thin sections. The sample, together with any necessary water, is placed in a platinum capsule after the manner of Goranson. One or more capsules are placed in a pressure bomb connected to a supply of inert gas (argon) at pressures up to 600 atmospheres.

The bomb is long and narrow, one end only being heated and kept slightly higher than the other in order to prevent convective circulation of the argon. The other end is tapered in diameter, protrudes from the furnace, and, because of the low thermal conductivity of the metal, does not get much hotter than 100° C. Consequent upon the heating the pressure undergoes a large increase, but may be reduced to any required figure by releasing excess argon. The pressure/temperature conditions are maintained until equilibrium has been reached or some chosen period has elapsed.

The capsules can be transferred from the hot to the cold end of the bomb by tilting the bomb to a vertical position, where they are rapidly quenched in dense cool gas. This is made possible by mounting the bomb on a pivot and by making the connecting pipe to the bomb of flexible steel tubing having an external diameter of only 0·110 in. The equilibrium may thus be 'frozen' and the contents of the quenched capsules subjected to petrographical examination.

The maximum pressure reached so far is 1,800 atmospheres (nearly 12 tons per square inch), corresponding to a depth of burial of about 23,000 ft. (nearly 7 km.). The temperature on this occasion was 650° C. At 1,000 atmospheres the apparatus has been operated at 870°C. Development of the apparatus to cover a wider range of conditions is proceeding.

The pressure bombs have hitherto been made throughout from 'Nimonic' creep-resistant nickel-chrome alloy, developed for use in turbo-jet aircraft engines. Care must be taken to see that critical temperature/pressure limits are not exceeded. About 1,000 hr. of running, devoted to a series of exploratory experiments, has been accomplished.

Thus artificial thermal metamorphism has been produced in slate, with decomposition of chlorite to orthorhombic pyroxene completed at 650° C. At higher temperatures (760° and above), idioblastic andalusite was well developed after 100 hr.

Certain members of the amphibole family have been synthesized at 500° C. and 1,000 atmospheres.

The calcium carbonate/silica reaction is being studied, and preliminary results suggest that under anhydrous conditions decarbonation may proceed only at higher temperatures than has been predicted.

Recent research. The importance of this type of experimentation is demonstrated by the results of recent research in the United States.

For example, silica in any form is commonly regarded as being completely insoluble in water at ordinary temperatures. Under low pressures of liquid water a slight solubility can be shown, but this drops almost to zero as the critical temperature is approached. Under pressures of the order of 1,000 atmospheres of water vapour, however, a different state of affairs is found, for with increasing temperature the solubility progressively increases and has been determined up to a value of about $\frac{1}{2}$ per cent. These observations are clearly relevant to some problems of silica transport.

Unquestionably the most important family of minerals in igneous and metamorphic rocks is the feldspar family. Microscopic, heat treatment and X-ray studies have shown the group to be complex. Dry-melt investigation of feldspar crystallization has been laborious because the alkali feldspars take weeks or months to crystallize; but, by contrast, crystallization is completed within an hour in the presence of water vapour at a pressure of one thousand atmospheres. Recent high-pressure work has confirmed the existence of a high-temperature series and of a low-temperature series of plagioclase feldspars, with the consequence that a number of difficulties attending the identification of feldspars in lavas and porphyries are well on the way towards being cleared up. A further most important conclusion is that the stability relations observed between the alkali feldspars and leucite under dry-melt conditions broadly apply in the presence of water vapour under pressure, crystallization temperatures being much reduced to figures quite compatible with our current notions of magmatic temperatures. The value of earlier dry-melt work is thus confirmed.

A further notable research is that on the system MgO–SiO_2–H_2O. The temperature/pressure stability curves for substances such as pure forsterite, olivine, serpentine, enstatite, talc and periclase in the presence of water have been determined. The conditions under which serpentinization may and may not take place in Nature have been indicated, and the conclusion has been drawn that neither a dunite magma nor a serpentine magma is likely ever to exist. A possible mechanism for the formation of dyke-like masses of olivine rock in pyroxenites, depending on silica transport by water vapour, has been outlined.

The future. That hydrothermal research will play an increasing and vital part in formulating petrogenetic theory seems certain.

The keystone of further progress must be the study of the hydrostatic phase equilibria. Certain problems, such as the progressive decarbonation of a siliceous dolomite, discussed by Bowen and Tilley, offer a prospect of unusual interest and elegance. Replacement phenomena will continue to be enigmatic until the relevant phase-equilibrium conditions have been determined.

A topic of great interest concerns the primary or secondary nature of the water so copiously evolved as steam during volcanic eruption, and is a reminder that our knowledge of the solubility of water in molten silicates is fragmentary. Goranson's work on granite melts, twenty years ago, requires extension to melts prepared from other igneous rock types. The carbonatites present an intriguing puzzle in this connexion.

Quantitative assessment is yet barely possible of the magnitude of the forces responsible for the penetrative shearing movement and preferred orientation demonstrated in some metamorphic fabrics. This problem is a challenge to experimental ingenuity and, in addition, calls for a study of the kinetics of mineral crystal disintegration and growth at the atomic level.

Large-scale diffusion has been put forward repeatedly as an important petrogenetic process by many petrologists. There is no branch of the subject where quantitative laboratory evidence is so scant, and where there is greater need for a strict physico-chemical treatment of the problem.

CHEMOTHERAPY OF TUBERCULOSIS

A COLLOQUIUM on the chemotherapy of tuberculosis was held in Dublin during July 10–13. It was sponsored by the Medical Research Council of Ireland, and the organization was in the hands of a small committee under the chairmanship of Dr. V. C. Barry. The meeting was international in character, the speakers being drawn from Great Britain, the United States, Germany, France and Ireland. There was a registered membership of 170, more than seventy of whom were overseas visitors, representing as well as the above countries, Switzerland, Holland and Sweden. The members came together for the first time on the eve of the opening at a reception given in Newman House by the President of University College and Mrs. Tierney.

The official opening of the colloquium in University College on July 10 was by the Minister for Health and Social Welfare, Dr. James Ryan. Prof. R. P. Farnan, chairman of the Medical Research Council, presided, and the attendance included the Taoiseach, Mr. de Valera. The colloquium was divided into seven sessions, each of which occupied a morning or afternoon. On Thursday afternoon the members had the honour of being received by the President of Ireland and Mrs. O'Kelly at Áras an Uachtaráin.

Each session was opened by a lecture and, after an interval for light refreshments, a discussion lasting about an hour and a half followed. The most interesting feature of the colloquium was that it brought together for four days the organic chemist and the biochemist, the bacteriologist, the pharmacologist and the clinician. The arrangement of the lectures was a logical one, beginning with the chemistry and biochemistry of the tubercle bacillus, followed by the organic chemists' approach to the problem of producing an adequate chemotherapeutic agent for tuberculosis. The story was continued with a description of the methods of preclinical evaluation of the agent. In the fourth lecture the present status of antibiotics in tuberculosis was assessed. At this stage the clinicians took over, and the last three lectures dealt with the thiosemicarbazones in tuberculosis, and the clinical evaluation of potential chemotherapeutic agents in pulmonary and urogenital tuberculosis. The formal and informal discussions which arose in this heterogeneous scientific gathering must prove of great value to all workers in this field.

Prof. Jessop presided at the first lecture, which was delivered by Dr. E. Lederer, on the chemistry and biochemistry of mycobacteria. This was an extensive review of the literature since 1940 on the carbohydrates, proteins and lipids of the bacilli. Dr. Lederer emphasized the extreme variability of the composition of mycobacteria and showed how it

depends on environmental factors and the age of the culture. Perhaps of greatest interest was his account of the researches of his colleagues and himself on the mycolic acids. Their probable formula is $C_{88}H_{176}O_4$, which contains a —COOH, an —OH and an —OCH_3 group. Pyrolysis of the mycolic acid at 300° *in vacuo* gives *n*-hexacosanoic acid, $C_{26}H_{52}O_2$; chromic acid oxidation yields among other products stearic acid, *n*-hexacosanoic acid, hexadecane and a 1 : 16-dicarboxylic acid. Chromatographic purification on alumina has led to the isolation of two distinct, and apparently isomeric, mycolic acids (α- and β-). Degradation experiments indicate that a mycolic acid is a high molecular weight β-hydroxy acid with a long aliphatic side-chain in the α-position (α-*n*-tetracosyl-β-hydroxy acid). The difference between the α- and β-acids must reside in the C_{38} fragment, which still awaits investigation. Human virulent strains of *Myco-tuberculosis* contain methoxylated mycolic acids, while the *H*37 *RA* avirulent strain contains an α-mycolic acid free from methoxyl. The interesting new amino-acid, α,ε-diamino-pimelic acid, which Work isolated for the first time from the diphtheria bacillus, has now been found in all strains of Mycobacteria so far examined. Among other matters of interest covered in the lecture was the problem of acid-fastness. It seems that all our present knowledge of this phenomenon can be explained by the observation of Yegian and Vanderlinde, who have shown that, in the stained bacterial cell, the greater part of the dye is in solution inside the cell. Its introduction is effected by heating with a phenol solution of fuchsin, and it cannot be removed by acid-alcohol washing since the cell wall is impermeable to this solvent. Boiling alcohol does remove the stain. Acid-fastness is probably due, therefore, to the presence of a characteristic mycolic acid containing lipopolysaccharide in the cell membrane.

During the discussion which followed, Dr. C. Iland referred to work carried out with Prof. M. Stacey's team at Birmingham. A urea extract of young living tubercle bacilli gives a complex material which has the biological properties of fresh unheated tuberculin. It yields an electrophoretically homogeneous protein which gives a complement fixation test with human tuberculous sera. The use of urea for extracting living cells may prove of particular value in providing cheaply a tuberculin skin-testing reagent. Prof. R. A. Q. O'Meara pointed out that the subject of Dr. Lederer's address was the end-products of mycobacterial metabolism; of greater importance from the point of view of chemotherapy are the products of the intermediate phases of metabolism, the substances which are most elusive are likely to be the most important. Dr. D. Twomey referred to the isolation of branched-chain fatty acids from other natural sources; for example, the *iso-* and *anteiso-*series of acids isolated from wool-fat, and phytomonic acid from *P. tumefaciens*. These latter acids probably exist as such in Nature, unlike phthioic acid, which is now known to be an artefact. Dr. Twomey also provoked a discussion on 'permeability', which he suggested exists as a crude conception in the minds of many chemists and biologists.

In the second lecture, Dr. V. C. Barry described an organic chemist's approach to the chemotherapy of tuberculosis. He reviewed the work of his team, which is a unit of the Medical Research Council of Ireland. They have produced some drugs of potential value in tuberculosis and leprosy. *B.*53, a dialkyl succinic acid half-ester, has been used successfully in the treatment of tuberculosis of the urinary bladder. This substance has low *in vitro* activity in the presence of serum. A planned synthetical approach led to the production of a series of long branched-chain hydroxyamines which are much less antagonized by serum. One of these, *B.*390, a branched-chain pentadecylamine derivative, has shown a suppressive effect in guinea pig tuberculosis when given orally. A series of long-chain alkylpyrrolidines and piperidines was also described. In Dr. Barry's experience, this was the first example of a fatty compound exhibiting anti-tubercular activity *in vivo*, and it provides some justification for the long preoccupation of workers in this field with substances of a fatty nature. Another aspect of the work showed the development from the lichen product, diploicin, by successive synthetical modifications, of a series of phenazine dyes highly active against the bacillus in serum broth. One of these, *B.*283 (2-anilino-3-imino-5-phenyl-phenazine), has shown a suppressive effect in mouse and guinea pig tuberculosis. Dr. Barry described six types of compound which up to date are known to modify the disease in the guinea pig. These were all produced empirically. The testing of antitubercular compounds in liquid media enriched by serum can be relied on to make possible the selection of agents likely to exhibit activity *in vivo*. Dr. J. Barnes exhibited a series of photographs showing the effect of *B.*283 in a series of cases of lepromatous leprosy in Nigeria. In his view, *B.*283 is more rapidly effective than any other drug in current use for the treatment of this form of leprosy. A very lively discussion followed to which Dr. D. A. Peak, Mr. F. A. Robinson, Prof. J. Algar, Dr. Lederer and others contributed. The discussion centred for the most part on the question of the empirical versus the rational approach to chemotherapy. It was remarkable for the high level of honesty sustained, there being general agreement that no successful chemotherapeutic agent has yet been discovered by a completely rational approach. Prof. T. S. Wheeler presided at this session.

Dr. W. H. Feldman spoke on the preclinical appraisal of antituberculosis agents. He emphasized that certain prerequisites must be satisfied before a given agent is considered worthy of clinical trial. This necessitates the collection of a considerable amount of data from many experimental studies. He discussed in detail *in vitro* testing, the *in vivo*–*in vitro* test and the conduct of many *in vivo* screening routines. These included the use of the chick embryo, the baby chick, the rabbit (intracorneal infection), the mouse, the hamster and the guinea pig. No summary of this lecture is possible. The refinement and careful control of Dr. Feldman's *in vivo* experiments are wholly admirable. However, animal experimentation is not an end in itself, and in the present writer's view there is a stage in its development when further elaboration may lead only to results of purely theoretical significance. In the discussion, Mr. Francis compared the pathology of the disease in the monkey, dog and smaller animals. The dog does not develop much allergy, and must be regarded as a resistant animal. Dr. J. Ungar expressed the belief that *in vitro* testing is valueless unless carried out in complex media rich in protein. Substances with marked reticulocytic stimulation influence mice more than guinea pigs. The effect of streptomycin in experimental tuberculosis in the mouse is quite different from that in the guinea pig. Further contributors to the discussion were Dr.

A. Q. Wells, Dr. Carmichael, Dr. Conalty and Mr. W. Freeman. Prof. F. S. Stewart presided.

In the fourth session, the chair was occupied by Prof. T. G. Moorhead. Dr. George Brownlee opened the proceedings with a talk on the present status of antibiotics in tuberculosis. This was a stimulating and original contribution, which characteristically had little relevance to the title. Dr. Brownlee described six biochemical lesions which follow invasion by a tubercle bacillus: multiplication of the parasite, chemiotaxis of monocytes, inhibition of proteases, hypersensitivity effect, skin allergy and acquired resistance. Specific antimicrobial chemotherapy is associated only with the first. Three factors influence the effect of chemotherapeutic agents on a bacterial population: the efficiency of the agent, the effect of the number of the organisms, and the rate of emergence of resistant strains. Dr. Brownlee dealt at length with the role of hypersensitivity in the spread of the disease. He visualized the advent of an anti-anaphylactic drug which will effectively modify tuberculin hypersensitivity. This may be expected to revolutionize our present-day concepts of the limitations of conventional chemotherapy of tuberculosis. He also expressed the opinion that the evidence appears to be complete that a chemical entity exists in suitably prepared dead tubercle bacilli, which is antigenic and protective. Though this substance may be labile in character, he believed that ways will be found of extracting it. Opening the discussion, Dr. D. G. Madigan described the treatment of a group of patients with bacillary emulsion under the cover of effective chemotherapy with streptomycin and *p*-aminosalicylic acid. In 50 per cent of patients, it is possible to achieve desensitization as measured by the skin test (to 1 in 10) in six weeks. Dr. P. Swift described the treatment of tuberculous meningitis with streptomycin. In his opinion it is not now justifiable to use streptomycin by itself. The remainder of the session was devoted to a lively discussion on the origin and nature of streptomycin resistance, in which Prof. Kennedy, Dr. D. A. Mitchison, Mr. G. W. Dawson, Dr. J. Crofton and Prof. Julius took part.

The second half of the colloquium opened in Trinity College with Dr. Gerhard Domagk's lecture, Prof. W. R. Fearon presiding. Prof. Domagk said that three compounds have been used in the treatment of chronic tuberculosis infection: the thiosemicarbazones (conteben), streptomycin and *p*-aminosalicylic acid. All three are active against different types of tubercle bacilli both *in vitro* and *in vivo*. In the experimental animal, a combination of conteben and streptomycin has proved more effective than streptomycin alone or any other combination. Side reactions at first attributed to the thiosemicarbazone itself are to some extent due to dead or damaged bacilli. It is possible to obtain extensive fatty degeneration of the liver by injection of dead bacilli only. The thiosemicarbazones are being used extensively in South America and Central Africa for the treatment of leprosy. In the discussion, Dr. A. R. Martin pointed out that *TB* III (*p*-ethylsulphonylbenzaldehyde thiosemicarbazone) is better tolerated in man than conteben and produces much higher blood-levels with equal dosage. Dr. Barnes described a trial which he has conducted with a series of cases of tuberculoid and lepromatous leprosy. Conteben was effective in the former type, but very much less effective with the latter. In reply to Mr. Francis, whose experience has been that none of the partially successful tuberculosis and leprosy drugs have any appreciable effect on rat leprosy, Dr. Domagk pointed out that the strain of leprosy bacillus infecting man is quite different from the rat leprosy bacillus. It also emerged from the discussion that there is little information available as to the effect of thiosemicarbazones on streptomycin-resistant strains of tubercle bacilli.

The sixth and seventh lectures were mainly of interest to clinicians. Dr. Marc Daniels spoke on "The Clinical Evaluation of Potential Chemotherapeutic Agents in Pulmonary Tuberculosis". He described the various rigorous procedures and teamwork which alone can make a clinical trial of a new drug of value. Prof. J. M. O'Connor presided.

At the final session, Prof. J. McGrath presiding, Mr. J. T. D. Lane described his experience in the treatment of a number of cases of renal tuberculosis with streptomycin and a smaller number with *B.*283. The latter cases had failed to respond to streptomycin. It was clear that both drugs are more effective when dealing with early lesions. He thought it likely that a combination of the two drugs may prove more effective than either alone. In vesical tuberculosis persisting after nephrectomy, *B.*53 appears to be very effective. In this type of case, in his experience, streptomycin is only effective when the lesions are superficial.

It was a highly successful and lively conference, owing much of its success to the presence of workers interested in every stage of the chemotherapy of the disease, to the logical arrangement of the programme and finally to the fact that the limited number of contributions did not produce the mental indigestion frequently associated with gatherings of this kind. The chemists' contributions were tinged somewhat with melancholy, but not completely despairing. The biologists were optimistic and fruitful in theories. The bacteriologists among them appeared to be quietly confident that their routine procedures were adequate to any demands that might be made on them. The clinicians, however, as instanced by Dr. E. T. Freeman, were polite but firm in pointing out that the desired chemotherapeutic agent for tuberculosis has yet to be discovered.

A complete record of the proceedings will be published later this year as a special issue of the *Irish Journal of Medical Science*. VINCENT C. BARRY

THE FAWLEY REFINERY

FOR the past two years, ever since the first grader started site-clearance in July 1949, the word 'Fawley' has taken on a new meaning in British oil circles. The place itself was of small consequence on a comparatively little-known peninsula between Beaulieu River and Southampton Water, save for the existence of the original Esso Petroleum Company's oil refinery, in operation for some thirty years past. All this has now changed. The new Esso refinery, officially opened by the Prime Minister on September 14, is an accomplished fact, a triumph of American and British brains and skill, a monument to the close ties binding the two countries in peace as well as in war.

The history of this outstanding example of initiative and enterprise is as impressive as is the vista of the whole complex plant itself. Begun in 1949, it was

actually completed this year four months ahead of schedule. The scheme involved clearing and levelling 450 acres of wooded gravel-land; construction of roads; laying down a railway system to connect up with permanent way to Southampton; erecting a huge building, 800 ft. long, 180 ft. wide and occupying more than 3 acres, first to house constructional materials, ultimately to serve as maintenance and machine shop; lay-out of a construction camp on site for 750 workmen; erection of a huge concrete plant with output of 140 cubic yards per hour, one of the largest in the world; installation of the main refinery units, in itself a colossal task of erecting and linking-up the bewildering maze of pipes, tanks, stills, furnaces and huge towers that go to make up a modern oil refinery. Add to this permanent houses for key-staff, a beautiful theatre and games building (social club) and it is at once obvious that the Fawley we used to know has been completely transformed into a self-contained city of potentially some 2,000 inhabitants; incidentally, some of the original inhabitants appeared to be almost Americanized.

A tour of the refinery during the day before the official opening provided unrivalled opportunity for studying the lay-out in technical detail. Crude oil is delivered by tanker to a specially constructed marine terminal, a 3,200-ft. jetty jutting into Southampton Water and connected to the main plant by a 2,000-ft. long approach road, constructed over salt marsh-land, carrying oil, steam and salt-water pipe-lines into the heart of the refinery itself. Thence fed to storage tanks, oil eventually passes through pipe-still furnaces to heat it up to 750° F.; thus vaporized, it enters the fractionating tower where condensation takes place at different levels on 'bubble trays'.

There are three fractionating towers here, two operating at atmospheric pressure, and a third under vacuum with steam distillation to deal with 'bottoms' from the other two. An outstanding feature is undoubtedly the huge catalytic cracking plant ('cat cracker') fed with gas oil, using a catalyst in an extremely fine state of particle division (technically known as 'fluid catalytic cracking'). A specially designed thermal-cracking plant converts lubricating oil and motor spirit into high-octane spirit plus gas. A polymerization plant determines increase in octane-rating of motor spirit obtained by distillation. A debutanizer tower, 113 ft. high, weighing 135 tons, separates butane and associated volatiles from motor spirit, designed to meet current vapour-pressure specifications. The copper sweetening unit removes corrosive compounds and evil-smelling vapours from motor spirit. Then there is the Edeleanu plant for improving burning qualities of kerosene; a hypochlorite plant for removing unpleasant sulphur compounds from kerosene and turbo-jet fuels; the lubricating oil plant, involving propane de-asphalting, phenol extraction, propane de-waxing and clay treatment processes. The oxidizing plant produces some well-known 'blown' grades of asphaltic bitumen; a 'specialty' unit manufactures anti-corrosive additives for lubricating oil; a hydro-desulphurization plant effects removal of sulphur from tractor-fuel.

In view of the serious shortage of sulphur at the present time, a vitally important unit under construction is the sulphur plant, for the conversion of hydrogen sulphide, released during varying stages of refining crude oil, into chemically pure 99·5 per cent rock sulphur. Full sulphur production is scheduled for early 1953; output will be of the order of 12,000 tons a year.

Fawley now assumes priority as the largest oil refinery in Europe. It cost £37,500,000 to build. When in full operation it will produce 6,500,000 tons of petroleum products a year; more than a million gallons of motor spirit a day; and nearly 30 per cent of present total demand for petroleum and products in the British Isles. Not least in these financially stringent times, this brilliantly planned and executed work will effect a saving in foreign exchange of more than 2 million dollars a week.

Someone concerned with the lavish series of publications which a great occasion like this official opening obviously presented had the foresight and sensitive imagination to commission H. E. Bates to write a commemoration "Fawley Achievement", "as a tribute to the vision, skill, and energy of all those who helped to plan and build it". Much praise was heard throughout the time of our tour of the new Fawley; but many read this tribute with a feeling that no one could have done it better than Bates, nor given to the sponsors of this great enterprise more encouragement for the future than is justly their due.

H. B. Milner

OBITUARIES

Mr. G. Udny Yule, C.B.E., F.R.S.

George Udny Yule was a member of a family distinguished for its scholarship and administrative talent. His father, Sir George Udny Yule, a very successful administrator in the Indian Civil Service, was one of three sons of Major William Yule, of the East India Company's service, who was born in 1764 and was in his day a well-known Orientalist; of the others, one, Lt.-Colonel Robert Abercromby Yule, a rising cavalry officer, was killed at Delhi in command of the 9th Lancers in 1857; the other, Colonel Sir Henry Yule, is remembered internationally for his authoritative edition of Marco Polo's travels. Udny Yule thus had an oral tradition of learning and of civil and military administration reaching back to the end of the eighteenth century. Udny Yule himself was educated at Winchester and University College, London. Science and engineering were his early interests, and he spent a postgraduate year under Hertz at Bonn on research into the passage of electric waves through dielectrics, which formed the subject of his first published paper. This field, however, was not very close to his heart, and he never reverted to it.

Udny Yule's scientific career proper began in 1893, when he joined Karl Pearson at University College, London, as lecturer in statistics. Pearson was laying the foundations of the science of theoretical statistics and it was not long before Yule himself was making fundamental contributions to the subject. For the next fifteen years he devoted himself mainly to the theory of statistical relationship, publishing basic memoirs on correlation (1897, 1907) and on association (1900). His work on association was later (1912) summarized in a further paper, and little has been added to it since; his work on correlation, in one form or another, continued throughout most of his life.

From 1902 onwards Yule gave a series of Newmarch Lectures which in 1911 were amplified and published as "An Introduction to the Theory of Statistics". This famous text-book remained for many years the only extensive account of the subject. There are very few students of statistics even to-day

who do not owe something to it. With numerous subsequent revisions it has reached its fourteenth edition and appears to be maintaining its place in spite of its now numerous competitors; it has been translated into several languages, notably Czech and Spanish.

In 1912 Yule went to Cambridge, where he became a Fellow of St. John's College and University reader in statistics. His academic career was interrupted by the First World War, and he spent the four years 1914–18 in the Contracts Department of the Board of Trade, his services being recognized by a C.B.E. Thereafter, scientific recognition followed by easy stages. He was elected a Fellow of the Royal Society in 1921, and president of the Royal Statistical Society in 1923, having been awarded that Society's highest honour, the Guy Medal in Gold, in 1911. He was honoured by several foreign societies and in 1947 was made an honorary member of the International Institute of Statistics.

During the phase from 1912 until 1927, Udny Yule's work fell into two classes. In conjunction with Major Greenwood he laid the foundations of the study of accident distributions, a subject which nowadays has a much wider field of application than when Yule began on it. His interest in statistical relationship found expression in a paper of 1921 on time correlation and one in 1926 on 'nonsense correlations'. His work culminated in a famous paper in 1927 on sunspots, which forms the starting point of the modern theory of oscillatory time-series.

In 1931 Yule retired and, characteristically, took up flying as a hobby. He was very proud of obtaining a pilot's certificate *A* at the age of sixty; but unfortunately his heart gave serious trouble shortly afterwards, and the remaining twenty years of his life were spent in comparative seclusion at Cambridge, which he rarely left.

His main scientific work was now at an end; but the literary and philological interests of his family began to show themselves. Moved by doubts cast on the traditional attribution of the authorship of the "Imitatio Christi" to Thomas à Kempis, he was led to a statistical study of literary vocabulary, on which he published his last book in 1944. His strength then failed, and during the closing years he was able to accomplish very little. He died at the Evelyn Nursing Home at Cambridge on June 26, 1951, at the age of eighty.

Yule's work is characterized by its originality, its thoroughness and a wonderful insight into the problems which he studied. A great many of the basic ideas of statistical theory can be traced back to his papers, where they find expression with the modesty and simplicity of genius. He was one of the statistical giants of his age. In spite of some provocation he never embarked on controversy, and his objectivity towards his fellow statisticians is without blemish. In character he was kindly and sociable, with opinions soundly based, firmly held but moderately expounded—a thoroughly lovable man.

M. G. KENDALL

WE regret to announce the following deaths:

Dr. K. C. Bailey, registrar of the University of Dublin, and during 1935–47 professor of physical chemistry in the University, aged fifty-five.

Sir Eric Maclagan, K.C.V.O., C.B.E., during 1924–45 director and secretary of the Victoria and Albert Museum, London, on September 14, aged seventy-two.

Prof. F. W. Oliver, F.R.S., emeritus professor of botany, University College, London, on September 14, aged eighty-seven.

NEWS and VIEWS

Higher Technological Education in Great Britain

THE statement of Government Policy for the Development of Higher Technological Education in Great Britain (London: H.M. Stationery Office, 3*d*. net) issued on September 20 sets forth the Government decisions on the report of the National Advisory Council on Education for Industry and Commerce, but gives little indication of real policy in either technical or technological education. The two are not clearly distinguished; but so far as the former is concerned, the policy would appear to be 'the mixture as before'. In regard to technological education, the chief feature is the rejection of the idea of a technological university, whether an entirely new institution or by the expansion of some existing institution. The cost of such a proposal is estimated at £6 millions, and its creation by either method is regarded as requiring too large a diversion of available resources. Instead, a policy of diversified expansion is to be pursued. The universities are to be encouraged to expand their existing departments in technology and to institute postgraduate courses in particular fields of technology, while the University Grants Committee is considering the possibility of expanding much more considerably at one or two places. On this side it will not be possible to pass judgment until the University Grants Committee indicates its proposals for the next quinquennium; but the Statement intimates that the Government proposals for making improved financial assistance available for selected technical colleges and courses will be announced shortly.

According to the Statement, some sixty technical colleges in England and Wales and six in Scotland provide higher technological education; but until these further details are made public it cannot be judged whether the proposed policy will yield any effective return and not lead to waste of resources through excessive diffusion. The Government has accepted the dubious proposal to establish a College of Technologists—though the use of the title 'Royal' is temporarily to be withheld—with responsibilities limited to granting awards of associateship, etc., and for the approval of courses for this purpose. Until the details of the Government's own proposals for selected technical colleges and those of the University Grants Committee in regard to the universities are made known, the value of the proposals cannot be judged. The trend of the Statement indicates a desire to court the favour of the universities and of the local education authorities, rather than to deal imaginatively with the real issues and to ensure that existing resources are used to the best advantage, from the national, and not from any sectional, point of view.

City and Guilds of London Institute

At a special general meeting of the members of the City and Guilds of London Institute, held at Skinners' Hall on September 21, H.R.H. the Duke of Edinburgh was elected president. The first president was King Edward VII, when Prince of Wales; but on his accession to the throne he became visitor in accordance with the Institute's Royal Charter granted in 1900, and the office had since remained vacant. This further connexion with the Royal Family is a high tribute to the Institute's independent work extending over a period of seventy years. It is also a reminder that much still remains to be done by all concerned with scientific and technological education, as the Duke of Edinburgh so clearly indicated in his presidential address to the British Association this year.

The Institute was founded by the Corporation and certain of the Livery Companies of the City of London in 1878, during the period which His Royal Highness described as the high-water mark of British industrial expansion. There was a great need for better scientific and technical grounding for those engaged in industry, and the Institute accordingly set itself to meet this need by founding Finsbury Technical College, the Central Institution (now the City and Guilds College) and the Art School at Kennington. Concurrently the Institute, having taken over the technical examinations of the Royal Society of Arts, began to build up the Department of Technology, the syllabuses and certificates of which are so well known to industry and to countless students and teachers in technical colleges. This is a long list to the credit of one body, and the common parentage is not always appreciated. The influence of each, from craft to professional level, on technological training and education has been considerable. This year recalls the 1851 Exhibition, which was also of practical significance to the Institute, for the City and Guilds College is among the educational institutions built on the site purchased with the proceeds of that great enterprise of Prince Albert.

United Nations Technical Assistance to Underdeveloped Countries

In view of the demands which the Colombo Plan and other schemes for technical assistance to the underdeveloped areas of the world may make upon British and other resources, particularly in scientific and technical man-power, the pamphlet "United Nations Work and Programmes for Technical Assistance" (pp. 40; New York: United Nations; London: H.M. Stationery Office; 1951; 15 cents. 1*s.*), issued by the United Nations Department of Public Information, makes a welcome appearance. Its forty pages contain a clear explanation of what is meant by technical assistance, how the programme came into being, the principles which determine the selection of experts or of projects, the way in which the programme works and is administered, and where the particular responsibilities lie, as well as the way in which it is related to other programmes of technical assistance. An annexe records the technical assistance given in 1950, including the countries aided, and a brief bibliography indicates where further information about the technical assistance work of the United Nations and the Specialized Agencies may be found. The pamphlet is strictly factual and should assist in the discussions of a subject that, as the recent report of the Advisory Council on Scientific Policy indicates, is likely to become increasingly important. While it outlines what is required of the assisted countries and should help to keep discussion free from prejudice, there is one important omission which doubtless is unavoidable in a pamphlet of this nature and length: it does not indicate the factors, such as population pressure, which may determine, independently of the merits of the programmes themselves, the success or failure of technical assistance. Such factors must receive full recognition in deciding on the allocation of limited scientific and technical resources, whether from the United Kingdom or elsewhere.

Natural Resources of Canada: Annual Departmental Report for 1948–49

The report of the Mines, Forests and Scientific Services Branch of the Department of Mines and Resources, Canada, for the year ended March 31, 1949 (pp. 117; Ottawa: King's Printer, 1950), which has been reprinted from the Department's annual report, covers the activities of the Bureau of Mines, Dominion Forest Service, Geological Survey of Canada, Surveys and Mapping Bureau, Dominion Water and Power Bureau, Geographical Bureau, National Museum of Canada and the Dominion Observatories. Special stress is laid upon the continued success of drilling operations in the new oil-fields in Alberta, and Canada's dependence on foreign supplies is expected to diminish considerably; besides a large increase in production for 1949, a considerable expansion of refining facilities was anticipated. Closely related to these developments are developments with natural gas which may markedly affect the economy of the country. There were also important developments in relation to iron ore, titanium and uranium. The salt industry continued to expand, as well as the forest industry, and exports of pulp and paper attained new records. Increasing attention is being given to the depletion of forests, and especially to more efficient utilization of the hewn wood, but losses through forest fires were again high. The Geological Survey's facilities for assisting in the search for radioactive minerals were extended, as well as those of its Geophysical Section for dealing with the plotting of magnetic data acquired with the airborne magnetometer. A pilot plant for the separation of bitumen from the bituminous sand of northern Alberta was ready for operation at the end of the year, and the practicability of structural steel welding in Canada under winter conditions has been demonstrated. Work on the use of red-stained jack-pine in sleepers and poles is likely to conserve timber supplies, and the Surveys and Mapping Bureau has been considerably expanded to meet the increased demand for maps in the study and development of Canada's natural resources.

Training for Social Work

An international survey of training for social work has been prepared by the United Nations Department of Social Affairs to provide the Social Commission and the Economic and Social Council with a detailed description and analysis of the methods of training of social workers in various countries. The study is based on reports submitted to the United Nations Secretariat and analyses the various conceptions of social work revealed in the definitions submitted. It also contains a survey of the general systems of education for social work that have been evolved for

the professional training of social workers. In addition, it presents a comparative analysis of the non-curricular and curricular aspects of schools of social work in forty-one countries; the general body of knowledge imparted to social work students; the general pedagogical methods used in the preparation of social workers; the administrative and financial aspects of schools of social work; the duration of the period of study; the relative importance assigned to the subjects included within the curriculum; and the methods by which theoretical knowledge and technical proficiency are imparted. The study also reviews United Nations' activities relating to training for social work and offers suggestions for future action in the national and international fields. Three useful appendixes contain statements of the definition of social work and the social worker received from various countries; a descriptive summary of the organization and programme of study of one school of social work in each of forty-one countries; and a directory of schools of social work in all countries which have established such schools. Copies of the document may be obtained from H.M. Stationery Office, price 15*s*.

National Research Development Corporation

THE President of the Board of Trade has made three new appointments to the membership of the Corporation, and has re-appointed those members whose initial period of service recently expired. The Corporation now comprises: Sir Percy Mills (*chairman*); Lord Halsbury (*managing director*); Prof. P. M. S. Blackett; Prof. E. C. Dodds; Sir John Duncanson; Sir Edward Hodgson; W. E. P. Johnson; J. F. Lockwood; Sir Rowland Smith; Sir Edward de Stein; and Sir Henry Tizard. The new members are: Mr. Lockwood, managing director of Henry Simon, Ltd., and a director of other engineering companies; Sir Rowland Smith, chairman of the Ford Motor Co. and chairman, or a director, of a number of associated companies; and Sir Henry Tizard, chairman of the Advisory Council on Scientific Policy and the Defence Research Policy Committee.

"Blue Sun and Moon"

REFERRING to their communication under this title on p. 554 of this issue, Dr. William Paul and Prof. R. V. Jones write: "Since our communication was written, Mr. R. R. Wilson, of the Royal Observatory, Edinburgh, has given an account, before Section A (Mathematics and Physics) of the British Association during the recent Edinburgh meeting, of his observations on the blue sun of September 26, 1950, and his deductions. Mr. Wilson succeeded in making spectrophotometric measurements of I_N/I_B for various wave-lengths, where I_B and I_N are the intensities of the blue and normal suns. The observed curve of log I_N/I_B against wave-length shows a minimum in the blue. Mr. Wilson has compared his results with theoretical curves as calculated by Van de Hulst and others and deduces a numerical value of $d\,(m-1)$, where d is the diameter of the scattering particles and m is the refractive index. He has discussed the probable nature of the scattering particles."

The Night Sky in October

NEW moon occurs on Oct. 1d. 01h. 57m., U.T., and full moon on Oct. 15d. 00h. 51m. The following conjunctions with the moon take place: Oct. 14d. 04h., Jupiter 5° S.; Oct. 26d. 17h., Mars 2° N.; Oct. 26d. 23h., Venus 0·04° S.; Oct. 28d. 18h., Saturn 5° N. In addition to these conjunctions with the moon, Mars is in conjunction with Regulus on Oct. 3d. 03h., Mars being 0·9° N. Mercury rises about an hour before the sun on October 1 and is in superior conjunction on October 13; it is too close to the sun to be seen during the remainder of the month. Venus, a morning star, rises at 3h. 10m., 2h. 40m. and 2h. 35m., on October 1, 15 and 31, respectively. The stellar magnitude of the planet is −4·3, and the visible portion of the disk varies between 0·20 and 0·42. Mars rises soon after 2h. throughout October and can be seen in the constellation Leo, close to Regulus early in the month. Jupiter is in opposition on October 3, rising early in the evening throughout the month and setting at 6h. 10m., 5h. 0m. and 3h. 50m., on October 1, 15 and 31, respectively. Saturn is too close to the sun in the early part of the month to be seen but rises 1h. 20m. before sunrise on October 15 and 2h. 40m. before sunrise on October 31. Occultations of stars brighter than magnitude 6 are as follows: Oct. 10d. 17h. 57·4m., δ Capr. (*D*); Oct. 10d. 18h. 50·4m., δ Capr. (*R*); Oct. 17d. 23h. 14·2m., *q* Taur. (*D*); Oct. 17d. 23h. 36·5m., 20 Taur. (*D*); Oct. 17d. 23h. 57·7m., 16 Taur. (*R*); Oct. 18d. 0h. 28·3m., *q* Taur. (*R*); Oct. 18d. 0h. 32·6m., 20 Taur. (*R*); Oct. 18d. 0h. 55·9 m., 21 Taur. (*R*). (*D*) and (*R*) refer to disappearance and reappearance, respectively, and the times refer to observations made at Greenwich. Strong moonlight towards the middle of the month will prevent good observations of the Orionid meteor shower.

Announcements

PROF. W. T. ASTBURY, professor of biomolecular structure, University of Leeds, has been elected a corresponding member of the Istituto Lombardo di Scienze e Lettere.

THE Lord President of the Council has appointed Sir Eric Rideal, professor of physical chemistry in King's College, University of London, to be a member of the Advisory Council for Scientific and Industrial Research from October 1. Prof. H. W. Melville retires from the Council on September 30, on completion of his period of service.

AN informal conference on cationic polymerization and related topics will be held in the University College of North Staffordshire during March 24–26, 1952. Intending contributors should send the titles of their papers not later than October 31, and summaries not later than January 15, 1952. The fee, comprising also meals and accommodation, will be approximately £3. All communications should be addressed to Dr. P. H. Plesch, The College, Keele, Staffs.

THE Meldola Medal is the gift of the Society of Maccabæans and is normally awarded annually. The next award will be made early in 1952 to the chemist who, being a British subject and less than thirty years of age on December 31, 1951, shows the most promise, as indicated by his or her published chemical work brought to the notice of the Council of the Royal Institute of Chemistry before December 31. Communications should be addressed to the President, Royal Institute of Chemistry, 30 Russell Square, London, W.C.1, the envelope being marked "Meldola Medal".

PHYSICS OF SOCIAL EQUILIBRIUM

THE paper read by Dr. R. Fürth, reader in theoretical physics in Birkbeck College, London, on August 15 at the Edinburgh meeting of the British Association under this title broke new ground, and the enterprise of the author is a welcome sign that the natural scientist is making even more strenuous endeavours than he has done in the past to apply the concepts he has developed to social problems. A large amount of the work which has been carried out in the 'natural' and 'social' worlds has always been of common interest to both, as, for example, the theories of evolution developed during the nineteenth century. Nothing but good can come from the sharing of ideas and co-operative endeavour, provided that there is a clear understanding that there are fundamental differences between, as it were, the 'climates' of the two worlds, and that what is useful and will prosper in one world will not necessarily survive in the other.

At the beginning of his paper, Dr. Fürth has underlined the dangers that beset us when this proviso is neglected. As he points out, the use of physical models for the understanding of social phenomena has often led to gross over-simplifications, and sometimes to disastrous misunderstandings. Examples cited in the paper include the familiar analogies which are drawn between the concepts of 'forces', 'balances' and 'equilibrium', which refer to the properties of solid structures, and the behaviour of social communities. The model of a rigid body is, in fact, often used in popular literature to explain the processes of social change. Expressions such as 'the swing of the political pendulum' have crept into everyday language, and the result, as Dr. Fürth points out, is to give the ordinary citizen the erroneous belief that "present difficulties will in due course resolve themselves automatically by the working of some miraculous social mechanism".

Dr. Fürth is, of course, correct when he finds the distinction between mechanical machines and social communities in the *voluntary* working of the latter, and in the *intelligent* co-operation which exists between its parts. But he tends to over-state his case when he argues that the use of statistical techniques in the analysis of human behaviour may tend to predictions that are "completely wrong". It is perfectly just to point out that "the fate of the spinning ball is in no way influenced by the results of previous games", and to argue that predictions of social, as contrasted with natural, events are often invalidated by the mere fact that they have been communicated to the persons whose behaviour was the subject of the experiment. But in this case the statistician's 'other things' are not 'equal', and the validity of statistical techniques is left unimpaired. Indeed, the value of prediction in the social field often lies in the fact that processes of social change can be set in motion to avoid the occurrence of such phenomena as population decline that would otherwise take place.

Dr. Fürth's criticism of statistical techniques is, surely, only valid if the end-product of social science is accepted as the understanding of the very purposes of human life itself, and few social scientists would be presumptuous enough to maintain anything so outrageously ambitious. The main achievements of social scientists during the past generation have been to demonstrate that the extent to which human society is, in fact, 'voluntary' and human co-operation 'intelligent', is very much less than the intelligent Victorian believed or the common-sense man of to-day assumes. It is the unconscious influences that determine our everyday behaviour, and the undirected processes that shape the structure and development of human societies, to which we are turning our attention in increasing degree, and it is in that area of human experience that the methods of the natural sciences are most directly applicable. To what extent the unconscious can and should be made conscious, and the undirected brought under control, remains to be seen. But much (perhaps everything) that makes for human survival depends on it.

Dr. Fürth ends his paper with a plea for the application of statistical mechanics, the branch of theoretical physics which has been developed for the theoretical treatment of many physical phenomena, to the problems of social organization. In so far as the principal field of application, as Dr. Fürth points out, has been to the physics of systems or 'assemblies' of very large numbers of identical particles, there is a strong probability that social scientists will find in this branch of knowledge a valuable means for unravelling the very baffling problems which arise from the interaction between the individuals which compose a social group or community. But to argue more than this at the present time is highly misleading. To compare (as Dr. Fürth does) the behaviour of 'communities' of crystals of pure substances with that of human societies is surely to create the confusions and encourage the errors which he so rightly deplores at the beginning of his paper. To ascribe the political stability of the United Kingdom and of the British Commonwealth of Nations to "the soundness of their structures on the physical principles of strength of material bodies" is, at least, a gross over-simplification. The value of "statistical mechanics" for the social scientist must first be demonstrated by painstaking experiment in the factory working group or the housing estate neighbourhood before such generalizations are permissible.

T. S. Simey

FIELD-WORK IN ZOOLOGY

A DISCUSSION on "Zoology at the Marine, Freshwater and Field Stations" was held in Section D (Zoology) of the British Association at Edinburgh on the morning of August 13. Mr. E. Ford, director of the Marine Station at Millport, opened the discussion by describing the development of marine stations in Great Britain and abroad. His own station at Millport had as its first home the *Ark*, originally a floating laboratory moored in a submerged quarry at Granton, Edinburgh. Whereas in former days the attitude was that of the general practitioner in the broad field of zoological inquiry, the present tendency is to think and work as specialists. Specialization not only canalizes aim and effort but also leads almost inevitably to specialized institutions. The majority of the stations in Great Britain were at first committed by constitution to study the life of fishes in the interests of British commercial fisheries.

To-day, however, the main responsibility for this highly important public service is exercised directly by the Government through its different fishery laboratories and its permanent boards and commissions. There are special staffs and special laboratories dealing with other aspects. The Oceanographic Laboratory in Edinburgh, engaged in a plankton survey by means of automatic plankton recorders towed behind commercial ships; the newly constituted National Institute of Oceanography, devoting special attention to marine physical science; and the new Institute of Seaweed Research were quoted as examples.

Mr. Ford believes that there is a limit to the size of the station, beyond which it begins to lose that priceless opportunity for close personal association between all within its walls. A station that is too small has limited activities; a station that is too large is an impersonal workshop, and not a meeting place for colleagues.

Dr. H. D. Slack described the field laboratory on the west shore of Loch Lomond which was established in 1946 by the Zoology Department of the University of Glasgow for the study of life in fresh water and of insect life on land. This, being purely an extension of the Department of Zoology, has the same dual role of research and teaching. In the undergraduate course during the summer term, the benthic fauna of the Loch along a transect from the shore forms a part of the practical work, together with methods of hydrological investigation and a study of the plankton. Students specializing in freshwater biology undertake a research problem for presentation as a thesis in their honours degree examination.

Loch Lomond is divided into two by the Highland Boundary Fault: a shallow southern portion not more than 30 metres deep on Lower Carboniferous and Devonian rocks, and a long and narrow northern part on Cambrian mica-schists and grits with a greatest depth of more than 200 metres. Preliminary investigations of the hydrological data show that a thermal stratification is established in the deeper portion in July, but not in the shallow portion. The Loch is in general oligotrophic in character, but less so in its southern than its northern half. How far this tallies with the distribution and quality of the fauna has still to be determined, for very few observations have been made on the fauna of the deeper waters. Perhaps the distribution of fishes may afford evidence of the Loch's differential evolution. A perch – pike stage has been reached in the lower loch, and roach are common below the Highland Boundary Fault, while brown trout are still numerous throughout the Loch and appear to be more so toward the northern end. Only a reference in an old statistical account of 1796 stands as evidence of char having once been present, but the powan (*Coregonus clupeoides*) is abundant. This fish lives for the most part in deep water, feeding on pelagic plankton, but appears in large shoals in littoral regions during the summer.

Prof. L. A. Harvey's paper on field zoology at Exeter was read for him in his absence by Mr. J. Delany. He described the development of an annual course on ecology organized as a fortnight's camp under canvas. This started with only two students in 1932, was thrown open to the Universities of Britain in 1935, and now accommodates up to thirty students with a staff of three or four teaching members. Ladram Bay near Sidmouth was selected as a site from which ready access to as wide a variety of habitats as possible could be had. The programme is varied each year according to the interests and needs of the students and also of the staff. But whatever the individual items, the major aim has been to teach the principles and practice of ecological investigation rather than merely to elucidate the ecological relations within any given habitat. Quantitative methods used include ¼-m. sq. transects on the shore and salt-marsh and on moorland and bog, the use of random squares for assessing, in particular, plant populations, methods of estimating hardness, salinity, oxygen content, *p*H of water and various methods of trapping small mammals and of estimating the vegetation pattern associated with their distribution. Special techniques have been used at different times for assessing grasshopper populations, quantitative scoops for mud and gravel communities in the River Otter and the like.

Prof. Harvey, after brief mention of a fortnight's course of field studies for teachers which continued for some years but is no longer arranged, described a third project, namely, the investigation of the ecology of Lundy Island in the Bristol Channel. The Lundy Field Society has been founded, membership of which is open to anyone interested, and by this means it is proposed to weld together the interests and activities of both professional biologists and amateur naturalists. So far this has been most successful on the ornithological side, and an ornithologist is maintained as warden. Considerable progress has been made on surveys of the shores of the Island. Here, within a very small compass, exists a high degree of variation—from extreme exposure on the granite of the west and south-west to full shelter on the east, while entirely different shore conformations are provided by the little tag of slate at the south-eastern tip.

Dr. J. P. Harding, in expressing a museum attitude to work at marine, freshwater and field stations, said that there are many problems in zoology which can be best attacked by uniting the efforts of workers in many different fields. Among the most important are those concerning the mechanisms of evolution and the origins of species. The museum worker has helped with these problems not only by naming, describing and classifying species, but also by studying their geographical distribution. Animals living at any one time in a small area such as the British Isles can be divided into a number of quite different species. Each species consists of a population of individuals distinguished from other species by the possession of a number of characters which, while they will vary to a greater or lesser extent from individual to individual, do not do so sufficiently for there to be any overlap between one species and the next. Over a large area, however, such as that of a continent, the population living at one end may be quite distinct from that at the other; but there may be a complete series of intermediate populations in between. The herring gull and the lesser black-backed gull provide a very good example. These behave in Great Britain as two quite distinct species with no intermediates; yet a continuous series of birds linking up the two can be found by studying these gulls throughout their geographical ranges. Herring gulls extend in North America from Labrador to Alaska, and lesser black-backed gulls in Europe from Norway to Siberia. The birds in Siberia are, however, very much more like the herring gulls of Alaska than the lesser black-backed gulls of Britain, although they are linked with the latter by a more-or-less continuous

population. This is an extreme case of a continuously varying species, the end members overlapping but not inter-breeding.

The museum man with large collections of specimens from all over the world is in a favourable position for studying this type of geographical distribution; but it is the field-worker who can best study local variations of physiological characters, and these, being more intimately concerned with the animals' welfare, are often of great adaptive value. The museum worker is constantly finding differences between his specimens and being unable to decide whether these are due to the effects of the environment or not; only someone in the field can find out for him.

The president of Section D (Dr. C. F. A. Pantin), Mr. J. Colman, Mr. H. C. Gilson, Prof. H. R. Hewer, Prof. A. D. Hobson and Dr. C. F. Hickling took part in the discussion which followed. Dr. Pantin drew a distinction between biology and the physical sciences; workers in either research or teaching in biology have to derive general principles from very complex situations. The solution of biological problems, he said, often comes from unexpected directions, and can only be appreciated by those with a direct contact with the animals themselves.

TRANSFER OF LIGHT ENERGY WITHIN THE PIGMENT SYSTEMS PRESENT IN PHOTOSYNTHESIZING CELLS

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IN investigations[1,2] on photosynthesis of diatoms, it was found that light quanta absorbed by the carotenoid fucoxanthin brought about as strong a fluorescence of chlorophyll *a* as light absorbed by chlorophyll *a* itself; thus, energy transfer occurs with an efficiency of one hundred per cent.

With more refined spectral methods, we have carried out a more general investigation of the energy transfer between pigments within the photosynthetic apparatus. The work covers the main groups of photosynthesizing organisms. Fluorescence spectra were determined by means of a monochromator and a slightly modified photoelectric A.C. amplifier as described by Milatz and Bloembergen[3]. Various wave-lengths of incident monochromatic light were used for exciting fluorescence; the absorption of the incident light in the cells was also determined. Action spectra of photosynthesis of the same organisms were determined by J. C. Goedheer in this Laboratory, using a polarographic method[4]. In some cases phototaxis action spectra, which may be assumed to correspond with the photosynthesis action spectra[5,6], have been measured with Manten's bacteriophotometer[5].

The main photosynthetic pigment in purple bacteria, bacteriochlorophyll, probably occurs in three distinct bacteriochlorophyll-proteins[7], distinguished by absorption maxima at 800, 850 and 890 mμ respectively. For the sake of convenience they will be called here *B* 800, *B* 850 and *B* 890.

By examining fluorescence spectra, it was found that only *B* 890 shows fluorescence.

Transfer of light energy from the carotenoids to *B* 890 was found to occur in *Chromatium* strain *D* and in a strain of *Rhodospirillum molischianum* with efficiencies of 35–40 and 50 per cent respectively. If complete transfer to *B* 890 occurred, the fluorescence action spectrum (corrected for absorption) would be proportional to the absorption spectrum of the bacteria, also between 450 and 550 mμ, in which region the absorption is mainly due to the carotenoids. If, on the other hand, no energy transfer to *B* 890 occurred, the fluorescence action spectrum would be proportional to the absorption spectrum of bacteriochlorophyll, and only a small activity for fluorescence excitation would be found between 450 and 550 mμ. The fluorescence action spectrum actually found (Fig. 1) proves that a partial transfer takes place. Fig. 1 further shows that the action spectrum for *B* 890-fluorescence is proportional to the action-spectrum for phototaxis (or photosynthesis). This indicates that the carotenoids take part in photosynthesis only by transferring their excitation energy to *B* 890.

Additional experiments in the infra-red region showed that *B* 800 and probably *B* 850 also transfer their excitation energy to *B* 890.

By determining fluorescence spectra for various wave-lengths of incident light, it was found that, in vital cultures of *Chlorella*, only chlorophyll *a* shows fluorescence. From the fluorescence action spectrum it could be concluded, in an analogous way as above, that an almost complete transfer of excitation energy from chlorophyll *b* to chlorophyll *a* occurs, which is in agreement with the high efficiency of chlorophyll *b* in photosynthesis.

In solutions of about 10^{-3} *M* of both pigments in acetone, transfer of energy from chlorophyll *b* to *a* was also established, the efficiency being about 50 per cent.

The rather complicated fluorescence spectra of the red algæ *Porphyra lacineata* and *Porphyridium cruentum* and also of the blue alga *Oscillatoria* sp. could be analysed reasonably well in terms of fluorescence spectra of chlorophyll *a*, of the phycobilins and of an unknown pigment with a fluorescence maximum at about 725 mμ.

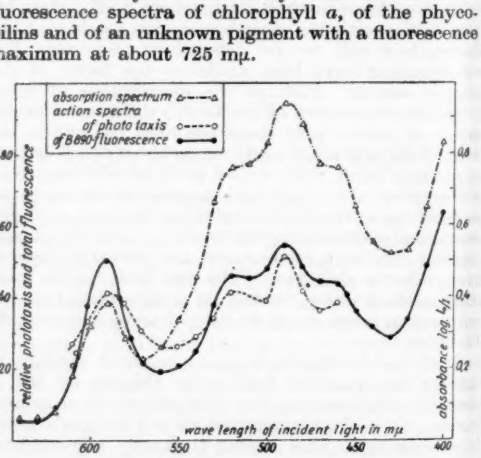

Fig. 1. Absorption spectrum, and action spectra for phototaxis and for *B* 890-fluorescence of *Chromatium* strain *D*. The absorption peak at 590 mμ is due to bacteriochlorophyll, the absorption between 450 and 550 mμ mainly to carotenoids. The carotenoids appear to be active with about the same efficiency both for phototaxis and for bacteriochlorophyll fluorescence. The fluorescence molecule is *B* 890 (see text)

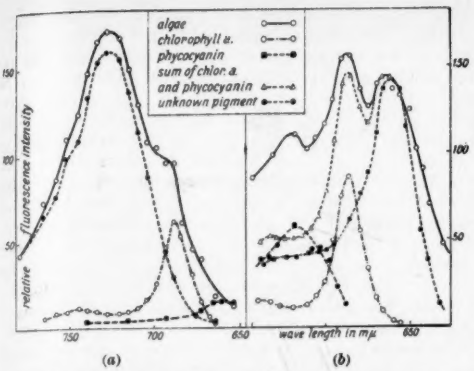

Fig. 2*a*. Fluorescence spectrum of *Porphyra lacineata*; relative fluorescence per quantum of incident light absorbed by chlorophyll *a* at 420 mμ (70 per cent of the absorption is due to chlorophyll *a*)

Fig. 2*b*. Fluorescence spectrum of *Porphyra lacineata*; fluorescence per quantum absorbed by all pigments at 546 mμ (approximately 70 per cent of the total absorption being due to phycoerythrin)

The fluorescence of chlorophyll *a* in *Porphyra lacineata* (Fig. 2*b*) per quantum absorbed by all pigments (incident light of wave-length 546 mμ) appears to be stronger than the chlorophyll *a* fluorescence (Fig. 2*a*) per quantum absorbed by chlorophyll *a* itself (incident light of wave-length 420 mμ). As the absorption at 546 mμ is mainly due to the phycobilins and chlorophyll *a*, it follows that quanta absorbed by the phycobilins excite chlorophyll *a* molecules to a stronger fluorescence than quanta absorbed by chlorophyll *a* itself. This surprisingly high yield of chlorophyll *a* fluorescence for light absorbed by the phycobilins, as compared with the yield for light absorbed by chlorophyll *a*, was also found—but still more pronounced—in the other species of blue and red algæ investigated.

From these observations it may be concluded, not only that chlorophyll *a* occurs in these cells in two different modifications, differing in fluorescence yield, but also that energy is transferred from the phycobilins to the highly fluorescent part of chlorophyll *a*, probably with high efficiency, and that consequently energy is not, or only to a slight degree, transferred to the weakly fluorescent chlorophyll *a* molecules. The weak fluorescence of these molecules in *Porphyra* may be due to transfer of energy to the above-mentioned unknown pigment, since its fluorescence is particularly strong (Fig. 2*a*) for the wave-lengths of incident light for which chlorophyll *a* fluorescence is comparatively low. The following observations support this view. By preliminary spectral and chromatographical investigations of *Porphyra* extracts carried out by F. van de Veerdonk in this Laboratory, a pigment was found—there are indications that it is chlorophyll *d*—of which the absorption was only about one-thousandth of that of chlorophyll *a* at the respective maxima of absorption. If we assume that this pigment occurs in *Porphyra* in the same ratio to chlorophyll *a* as in the extracts, its absorption is too small to be responsible for the strong fluorescence found. Therefore this fluorescence can only be due to energy-transfer from another pigment.

Energy transfer was also established in the red algæ from phycoerythrin to phycocyanin with an efficiency of probably more than 80 per cent in *Porphyridium cruentum*, and also from phycocyanin to chlorophyll *a* with about the same efficiency as from phycoerythrin. In these experiments, the wave-lengths of incident light exciting the fluorescence were: 546 mμ, mainly absorbed by phycoerythrin, and 600 mμ, mainly absorbed by phycocyanin.

Prof. C. S. French, working with *Porphyridium* at about the same time, kindly sent me action spectra, for incident light in the region 400–550 mμ, for the fluorescence of chlorophyll *a*, phycoerythrin, and phycocyanin. The action spectrum for chlorophyll *a* fluorescence demonstrates in an elegant way the low yield which occurs in the region in which chlorophyll *a* is mainly absorbing, as compared with the region in which phycoerythrin is mainly absorbing. The action spectra suggest, as Prof. French remarks, that light energy is transferred from phycoerythrin via phycocyanin to chlorophyll *a*. Hence our results seem to be in good accordance with his.

Light absorbed by the phycobilins proved to be more active in photosynthesis than light absorbed by chlorophyll *a*, as was previously established by Haxo and Blinks[4] for other species of red and blue algæ. Owing to experimental difficulties, hitherto we could only establish qualitatively the parallelism between the yield of chlorophyll *a* fluorescence and photosynthesis in red and blue algæ. Considering the position in other groups of organisms already described, we put forward the following picture of the two paths of energy transfer in red algæ:

(1) Phycoerythrin → phycocyanin → chlorophyll *a* → photosynthesis
↘ ↘ ↘
fluorescence fluorescence fluorescence and other energy losses.

(2) Weakly fluorescent chlorophyll *a* → unknown pigment → fluorescence and other energy losses.
↘
heat and other energy losses

In the blue alga *Oscillatoria* the path of energy transfer was found to be the same, the only difference being that phycoerythrin is lacking. It should be emphasized, however, that in *Porphyra* the fluorescence of the unknown pigment is more pronounced than in the other species of red and blue algæ; so the energy transfer from the weakly fluorescent part of the chlorophyll *a* to this pigment is only assumed on grounds of analogy.

The transfer of electronic excitation energy between pigment molecules as reported above probably takes place through inductive resonance between the excited molecules and the molecules in the ground-state, a theory for which Förster[5] has given a quantum-mechanical treatment, with the aid of which the probability of energy transfer can be calculated from experimental data. Estimations, based on Förster's considerations, are in accordance with, or at least do not contradict, the results recorded above.

Summarizing, we may say that the evidence obtained is in favour of the view that, in algæ, light energy absorbed by a pigment, active in photosynthesis, is transferred to the 'chemical' part of photosynthesis only via chlorophyll *a*, and in purple bacteria only via bacteriochlorophyll *B* 890.

A detailed report of this and related work will be published elsewhere.

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CONFIGURATION OF POLYPEPTIDE CHAINS

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AND
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We have recently formulated a number of configurations of polypeptide chains that differ from all those previously discussed in that they conform rigorously to the structural principles that have been set up on the basis of the precise X-ray studies of crystals of amino-acids, simple peptides, and related substances that have been made in our Laboratories during the past fifteen years[1-3,5,8]. In the proposed configurations, the interatomic distances and bond angles have the values found experimentally, the amide groups are planar, and hydrogen bonds N—H...O are formed with the N—O distance 2·8 A. and with the oxygen atom close to the N—H axis. Agreement in dimensions of units of structure and in observed and calculated intensities of X-ray diffraction maxima has provided strong evidence that these configurations are present in various synthetic polypeptides[4] and fibrous proteins[6-8], and also in hæmoglobin[9].

Perutz has recently suggested[10] a way of testing for the presence of our 3·7-residue helix, which he describes as "a simple and decisive criterion in the X-ray diffraction pattern". In the 3·7-residue helix (which we call the α-helix) there are approximately 3·7 residues per turn of the helix, which has a pitch of about 5·55 A., and thus the axial length per residue is 1·5 A. Perutz has pointed out that the form factor for the helix would show a strong maximum in the meridional direction at the spacing 1·5 A., and that accordingly synthetic polypeptides and proteins with this helical structure would be expected to produce a diffraction maximum at the spacing 1·5 A., if the specimen be suitably oriented. He found that the reflexion is given by poly-γ-benzyl-L-glutamate, hair, and porcupine quill-tip, but not by hair stretched to the β-form. He concluded that the "presence of this reflexion does not in itself prove the correctness of Pauling and Corey's structure, but taken in conjunction with the favourable agreement of observed and calculated intensities of other reflexions already obtained by these authors, it leaves little doubt about their structure being right". It should be mentioned that we had previously mentioned the existence and significance of the 1·5-A. reflexion, in the following words (ref. 7): "We would expect that side chains of different kinds on the α helix would repeat after an integral number of residues, corresponding to an integral multiple of the residue length along the helix axis, about 1·53 A, and that accordingly those orders of basal plane reflection for which the spacing approximated closely to certain multiples of 1·53 A. would be enhanced in intensity. It is in fact found that about 80 per cent of the meridional reflections are of this type; for both Venus clam muscle and porcupine quill they are multiples of 1·51 A. The reflections at 1·49 A, 3·05 A, 4·50 A, and 6·19 A for porcupine quill, which represent the first four orders of enhancement, are the strongest features of the wide-angle meridional pattern, except for the 5·2-A arc."

Perutz also looked for the 1·5-A. reflexion on X-ray photographs of feather rachis keratin, for which we suggested a structure involving 3·7-residue helixes as well as pleated sheets of extended chains[6], and he states: "Prolonged exposure of seagull's feather rachis set at the appropriate Bragg angle revealed no trace of such a reflexion, which shows that the structure proposed by Pauling and Corey must be wrong". (We may add that we have recently discovered a type of pleated sheet differing somewhat from that described in our earlier papers; this new pleated sheet, with alternate chains reversed in direction, might be present in feather rachis keratin and other proteins, instead of the polar pleated sheet.)

We agree with Perutz that the 1·5-A. reflexion is an important criterion for the 3·7-residue helix, but our assessment of the significance of the absence of this reflexion differs from that of Perutz. We agree with him that the presence of the reflexion does not in itself rigorously prove the presence of the 3·7-residue helix, but that a strong reflexion in the right position relative to the fibre axis direction and with spacing in the range 1·46–1·55 A. is to be taken as very strong evidence of the presence of the α-helix. On the other hand, Perutz, as shown by his statement about feather rachis quoted above, has assumed that the absence of such a reflexion rigorously eliminates the α-helix from consideration. This is not true. For example, a protein or synthetic polypeptide might have a structure involving α-helixes packed together in such a way that half the helixes are displaced along the fibre axis relative to the other half by an odd multiple of 0·75 A. In this case the radiation scattered by one chain in the direction giving rise to the 1·5-A. reflexion would be exactly out of phase with the radiation scattered by a neighbouring chain, and interference would result which would cause the intensity of this reflexion to be zero. We hence conclude that the presence of the 1·5-A. reflexion is to be taken as strong evidence of the presence of polypeptide chains with the 3·7-residue helical configuration, but that the absence of this reflexion is not to be taken as strong evidence of the absence of the 3·7-residue configuration; it indicates either that these helixes are not present, or that they are present but are arranged in such a way as to produce strong inter-chain interference for this reflexion.

Let us consider as an example the crystalline synthetic polypeptide poly-γ-benzyl-L-glutamate, which we have described[4], on the basis of data published by Bamford, Hanby and Happey[11], as having a monoclinic (pseudo-orthorhombic) structure involving two polypeptide chains per unit, these chains having the 3·7-residue configuration, with eleven residues in three turns. The two chains in the unit

appear to be related by a two-fold axis or a two-fold screw axis. If they were related by a two-fold axis the 1·5-A. reflexion would be expected to appear. If, on the other hand, they were related by the two-fold screw axis the two chains would be displaced along the direction of the fibre axis relative to one another by one-half the identity distance, that is, by one-half the distance occupied by eleven residues, and hence by an odd multiple (eleven) of 0·75 A.; the structure factor for the 1·5-A. reflexion (the reflexion 0.11.0 from the unit with fibre axis length $b_0 = 17·3$ A.) would be 0, and this reflexion would not be observed. The fact that Perutz has observed this reflexion for poly-γ-benzyl-L-glutamate shows that the two chains in the unit are not related by a two-fold screw axis.

Feather rachis keratin is similar, in that the structure which we have proposed for this protein involves two helical chains with the 3·7-residue configuration per unit of structure. We point out that there is a reasonable probability that the two α-helixes are displaced relative to one another by 0·75 A. or an odd multiple of this distance, which would lead to zero intensity for the 1·5-A. reflexion, and that accordingly Perutz's statement that "the structure proposed by Pauling and Corey must be wrong" is not justified. As to the structure itself, we may mention that we have proposed it for feather rachis keratin with some reserve, whereas our assignment of the 3·7-residue helix to the synthetic polypeptides poly-γ-methyl-L-glutamate and poly-γ-benzyl-L-glutamate and to α-keratin, α-myosin and related proteins, as well as to the rods discovered by Perutz and his co-workers in the hæmoglobin molecule[12,13], was made with much confidence, as was also our assignment of the three-chain helical structure to the fibrous proteins of the collagen–gelatin group. Our comparison of calculated and observed intensities of equatorial X-ray reflexions of feather rachis keratin provides some support for our proposed structure, but the support is far from conclusive. The statement by Ambrose and Elliott[14] that the infra-red spectrum of feather rachis indicates the presence of hydrogen bonds oriented parallel to the fibre axis as well as laterally also provides some support for the proposed structure, inasmuch as the α-helices involve parallel hydrogen bonds, those for the pleated sheet being lateral. Perutz's failure to observe the 1·5-A. reflexion does not eliminate this structure from consideration.

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Polypeptide Chains in Muscle

In a recent paper on the configuration of polypeptide chains in keratin, myosin and related proteins[1], we have discussed a mechanism of the contraction of muscle, involving the conversion of the contractile protein from a pleated sheet of nearly completely extended polypeptide chains to a double row of 3·7-residual helixes. Through oversight we omitted to discuss the apparent incompatibility of our proposal with the X-ray data of Astbury and Dickinson[2], who reported a number of years ago that both extended and contracted muscle give X-ray photographs of the α-keratin type. Our attention has been directed to the oversight by several correspondents, and by a note by Huxley and Perutz[3], who have found that both extended and contracted dried frog sartorius muscle show the 1·5-A. reflexion characteristic of the 3·7-residue helix, and proposed by Perutz[4] as a criterion for the presence of this helix.

There are several different proteins present in muscle, and we think that it is likely that the protein which makes the greatest contribution to the X-ray diffraction pattern is not the one which undergoes significant structural change during the process of contraction. We suggest that the structural units 100 to 200 A. wide and 200 or 300 A. long, indicated by electron micrography to be attached together in a muscle fibril, consist of boxes made of α-keratin (and perhaps also in part of collagen), within each of which there are strung (in the extended fibril) pleated sheets of the contractile protein between the two ends connecting the box with the adjacent boxes in the fibril. We think it likely that the pleated sheets of contractile protein are not packed together in the way that they are in dried β-keratin or in silk fibroin, but are instead separated from one another by layers of solution which may be 50 A. thick, this separation permitting the easy access of solute molecules to the contractile protein. With such an arrangement of pleated sheets the characteristic β-keratin X-ray pattern would not be observed; the relative positions of pleated sheets so widely separated from one another would probably be sufficiently random to cause the aggregate to give rise only to a diffuse diffraction pattern, not much different from the molecular form factor for a single pleated sheet. In the extended muscle, the non-contractile α-keratin oriented parallel to the fibre axis of the muscle would give rise to the X-ray pattern reported by Astbury and Dickinson and by Huxley and Perutz. On contraction of the muscle the pleated sheets of contractile protein would be converted, according to our suggestion, into α-helixes, which would be well oriented with respect to the fibre axis of the muscle, whereas the non-contractile protein of the α-keratin type would become somewhat disoriented, as a result of the shortening of the structural unit of which, we postulate, it forms the framework. This structure could thus also account for the X-ray observations of Astbury and Dickinson and of Huxley and Perutz on contracted muscle.

We have proposed this mechanism of muscle contraction as a reasonable one, which is compatible with our present knowledge of the structural chemistry of polypeptide chains, and which accounts for the usually observed extent of contraction of muscle, namely, about 55 per cent. Although, as shown by the preceding discussion, the interpretation of the X-ray pattern will not be simple, a very thorough X-ray investigation might reveal the structure of the contractile protein as well as of the non-contractile protein in muscle. [August 10.

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HIGH-POWER PHOTO-FLASH TUBES

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IT is of very great advantage to be able to extend to cinematography, involving ultra-rapid exposures (less than 10^{-4} sec. duration) repeated at the requisite frequency over a long working time, the type of flash-tube which hitherto has been limited to use in simple photography with single exposures or with exposures taken at long intervals. This extension, however, presents entirely new problems in regard to the construction of such tubes. When flashes, each dissipating energy $W = \frac{1}{2}CV^2$ (energy of a condenser discharge), are repeated at the frequency n per sec., the average power dissipated over the working time t of the tubes is $\frac{1}{2}nCV^2$ watts. Flash tubes as at present constructed dissipate powers of less than 20 watts; for example, those giving a maximum of one flash of 100 joules every 5 sec.

We have made some progress in developing high-power tubes, which will operate, for example, at some hundreds of watts for a long working time, or at some kilowatts over a period of a few seconds. The following are the main principles of the design:

(1) The general dimensions, particularly the tube cross-section, are very large in order to permit adequate cooling.

(2) Instead of using internal electrodes, the electrodes form part of the envelope of the tube. The Kovar electrodes are joined to the glass (Moly glass) forming the rest of the tube by means of a gas-tight solder seal. The external surface of the electrodes is cooled by direct contact with the outside air; the cooling may be improved by the use of fins, or by the circulation of compressed air or water.

(3) When the tubes are used as optical sources, it is nearly always necessary to locate the light source in some definite position. This result is obtained by means of an axial canalizing tube (Fig. 1) of small section. This tube is made of quartz because of the high temperatures it has to withstand; and its diameter, of a few millimetres, is chosen so that the current density may attain values corresponding to the maximum light efficiency. In order that the discharge should pass only through this canalizing tube and not through the annular space between it and the envelope, the canalizing tube is extended by two bell-shaped ends B_1 and B_2 inside which each electrode projects towards the inside of the tube. This arrangement, which makes the discharge path through the canalizing tube shorter than any path passing through the annular space, was found to be completely efficient.

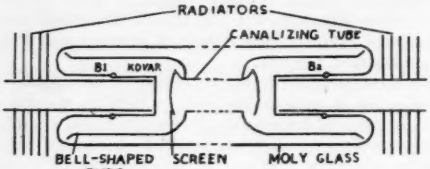


Fig. 1

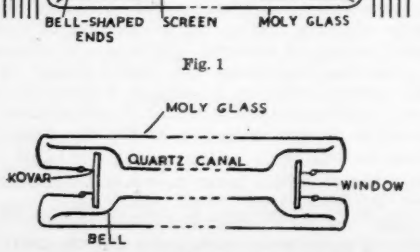


Fig. 2

(4) Intense pulverization of the cathode occurs in these high-power tubes, so producing an opaque deposit on the walls of the canalizing tube, which should be kept transparent. Owing to the fact that the metallic particles shot off from the cathode travel in straight lines, the canalizing tube can be kept transparent by placing a screen between it and the cathode, or by bending the tube at the cathode end.

Figs. 1 and 2 show two models of high-power flash-tubes which have been constructed in accordance with the above principles. That of Fig. 1 is used to make moving pictures, and operates for prolonged periods with an input power of 500 watts at the rate of 50 flashes/sec. (two flashes for one image). In the other model (Fig. 2) the extra high brilliance of the emitting tube at its end can be utilized, and in this case the cylindrical electrodes are sealed by Moly glass soldered to the metal by high-frequency heating[1]. This tube has made possible, for the first time, cinematography of living non-stained preparations with a phase-contrast microscope. The energy of a flash is about 10 joules, so that the tube must operate with an input of 1 kilowatt for a series of exposures at the rate of 100 images per sec.[2].

[1] Laporte, M., *J. Phys.*, **11**, 41 (1950).
[2] Laporte, M., Roerich-Goussu, O., and Dejean, J., *C.R. Acad. Sci., Paris*, **232**, 394 (1951); *Le Vide*, No. 31, 926 (1951).

LEARNING ABILITIES OF BIRDS

A COMPREHENSIVE and meritorious survey of existing knowledge of the learning abilities of birds and their relation to the theory of instinctive behaviour has been set out in two recent articles by W. H. Thorpe (*Ibis*, **93**, Nos. 1 and 2; January and April 1951). It is pointed out that the concepts of instinct and of learning are intimately related as complementary aspects of total behaviour, and that one cannot be understood without the other. Besides the definitions necessary for the description of instinctive behaviour and of learning itself, Thorpe also suggests definitions for certain other terms like reflex, kinesis, and taxis which are necessary for the full description of behaviour. The following is a summary of Thorpe's main conclusions.

Habituation is considered to be, in many respects, the simplest type of learning, and is one which is almost universal in animals. It is shown to be of vital importance in the process of adapting behaviour to generalized environmental stimuli (for example, sudden sounds, shadows and movements) which may be precursors of danger, but which experience has, in fact, shown to be harmless or of no significance. Habituation is thus caused by some stimulus or situation which puts the animal into a given mood but fails to lead to the release of a particular consummatory act. The more closely linked a stimulus situation (sign stimulus) is with a specific instinctive act, the less likely it is to be the subject of habituation.

The classical conditioned reflex is shown to be an artificially isolated part of a whole learning process and is only intelligible biologically as part of such a process. As with habituation, it is primarily one of the methods by which innate receptory correlates of

the less specific kinds are elaborated to fit the environmental situation more exactly.

Trial-and-error learning incorporates an active appetitive behaviour which constitutes the process of trial and is characterized by the retroactive action of the influence exerted by the reward. Trial-and-error learning is shown to be of immense importance in the development of bird behaviour, particularly on the effector side, in the acquisition of skill involved in the perfection of elaborate behaviour patterns, such as flight, nest-building and escaping from enemies. On the receptor side of such behaviour the conditioning element in trial-and-error learning leads to modification of the configuration of stimuli to which the animal is responding. Trial-and-error learning also serves to account for many examples of learning with puzzle-boxes and mazes. The learning function of play in improving skill is considered as a phase and is more prevalent in young birds than is usually thought. The danger of confusing maturation of an innate behaviour pattern with improvement due to trial-and-error learning is stressed.

Under this head of insight learning, Thorpe discusses the type of exploratory learning now known as latent learning, and its significance in the establishment of territory; tool using and detour behaviour are also possible examples of insight learning. In an analysis of recent work on the number concept in birds, Thorpe suggests that Kohler's conclusions that certain birds show two pre-linguistic faculties, (1) simultaneous and (2) successive, *unnamed* number sense, little, if at all, inferior to that of man, must be accepted as proved. The essential difference, therefore, between the number concept of animals and men is that only the latter have, in addition, the ability to deal with 'named' numbers. The significance of visual illusion experiments for the theory of insight learning is also considered, as are some other learning abilities suggestive of insight.

Analysis of the imitative abilities of birds suggests that a distinction must be made between social facilitation, local enhancement and true imitation. The first two play an important part in bird life, but the evidence for true imitation is at present very slender; vocal 'imitation' is not considered necessarily to involve imitation in the true sense.

Discussing imprinting as an innate disposition to learn in a particular direction and in a particular restricted period, it is believed that, once accomplished, this type of learning is particularly difficult to eradicate and is significant in understanding the theory of instinctive behaviour, and especially of the innate releasive mechanism. The important evidence supplied by pathological imperfections in imprinting is examined while the perceptory side of song learning is considered as a special case of imprinting.

Some learning abilities are of doubtful significance, the most important of these being the ability to recognize individuals. The subject of tameness is also discussed, and, in Thorpe's view, genetic tameness and wildness are undoubted realities. No evidence is found for an inherited recognition of man as an enemy, but it is shown that a tendency to general wariness readily becomes attached to man, but can be overcome by a variety of learning processes.

The memory powers of birds are also considered; instances of memory for individuals extending for periods of a year or more are well authenticated, and it is possible that memory for territory is often still more enduring.

MANAGEMENT PROBLEMS AND LOCAL GOVERNMENT

IN the most recent occasional paper of the British Institute of Management, Mr. J. E. MacColl suggests that, though latent for many years, there is a crisis in local government which has been made more acute by the stresses of post-war reconstruction.

Because of this stress, there has been a trend of functions from small authorities to large, and from large authorities to the central government. From a purely administrative point of view "large local authorities are more likely to be effective instruments than small ones. For many purposes the central government may be the most effective of the lot." But in our desire to produce maximum administrative effectiveness, care must be taken not to overthrow democracy itself. Mr. MacColl states that highly efficient local government departments are not necessarily satisfactory, and humanity, imagination and sensitiveness to local feeling are no less important than costs per head. People should not feel that their communal services are supplied from above regardless of their likes and dislikes, the ultimate test in a local democracy being whether the citizens find their town a pleasant place to live in and whether they feel responsible for what is done in their name.

Nevertheless, local government must be assessed by efficient criteria, and, in the first place, it must be acknowledged that much inefficiency has nothing at all to do with the limitations set by democratic control. In the second place, it is desirable to know what, in fact, are the costs of democracy. It is dangerously easy for councillors to ask for this return or that without any idea of what it really means in terms of extra cost. Mr. MacColl also discusses the lack of any adequate check on the number of staff in local government services. Although local government officers and especially senior officers work hard, much of their work could either be avoided or lightened. Each extension of intensification of activity leads to a demand for more staff, who really are needed unless or until somebody starts at the beginning to recast the whole administrative scheme.

As the amount of work a local authority is called upon to do increases, more and more staff are employed, extra office space taken over and a rich variety of forms designed. There is pressure from committees to speed up output of houses or to open new branches of the public library, pressure occasionally punctuated by panic when increases of rates threaten. The process goes on without anyone asking whether the load could be carried more efficiently or shared more evenly; perhaps without anyone having a clear idea how to set about finding this out. These difficulties are accentuated by excessive departmentalization and the absence of a general manager. Although it may be disturbing to those with orthodox views of British local government, there may be need for a hybrid political administrator to make the kind of contribution of the burgomaster or the American mayor.

Mr. MacColl also discusses the kind of men and women who are needed in local government service, and the relationships which should exist between the paid officers and the lay councillors. One of the crucial issues to be decided is whether it is more important to have highly trained and expensive administrators, or men and women who understand the peculiarities and idiosyncrasies of their own locality.

T. H. HAWKINS

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Blue Sun and Moon

Although the blue sun and moon are noteworthy phenomena, the physical origin of the colour does not appear to be well known. While, therefore, the following explanation is presumably neither novel nor complete, it may interest those who wish for "the vivid colouring of a physical illustration".

The cause of the sun appearing red has long been known to be due to the preferential scattering of blue light relative to red by dust particles and to small-scale fluctuations in refractive index in the atmosphere. Rayleigh showed that for particles of any given size much smaller than the wave-length, the scattering of radiation is inversely proportional to the fourth power of the wave-length; thus, for particles of less than 0·1 micron in diameter, light of wave-length 4000 A. would be scattered nine times more effectively than light of wave-length 7000 A. For the sun to appear blue, the relative magnitudes of scattering must be opposite to those which the Rayleigh theory predicts. This opposite condition can arise when the particles do not obey Rayleigh's criterion of being small compared with the wave-length.

The theory of scattering of electromagnetic radiation by spherical particles above the Rayleigh limit was first worked out by Mie[1], and extensive computations have since been made, by several workers, of the scattering under different conditions. Fig. 1 shows, for example, a curve derived by a method due to van de Hulst[2] of the variation with wave-length of the 'extinction' produced by a dielectric sphere. 'Extinction' is defined as the ratio of the effective cross-section over which radiation is stopped or diverted by a body to the geometrical cross-section which the body presents to the incident radiation.

A qualitative explanation of the main features of the curve can be given without going into detailed theory, and for this purpose the curve may be divided into three regions. The first (*A*) is the Rayleigh region, where the particle radius r is small compared with the wave-length λ, and the curve from the origin obeys the fourth-power law. The third region (*C*) is where the sphere is much larger than the wave-length; here it can be shown that not only does the sphere divert by refraction or reflexion all the radiation that falls upon it, but that it also diverts an equal amount by diffraction in the region around its edges. This fact, of which Walton[3], for example, gives a simple explanation, produces an extinction

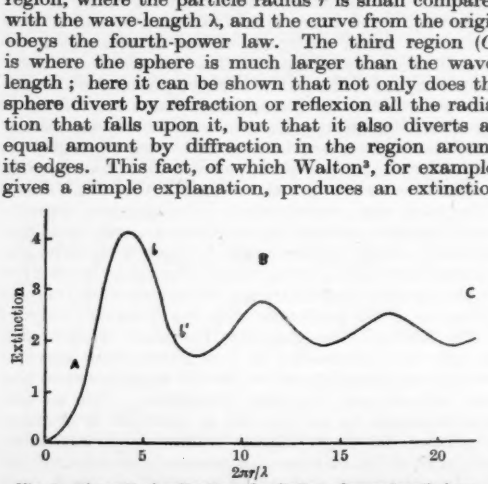


Fig. 1. Theoretical extinction of radiation of wave-length λ produced by a dielectric sphere of radius r, and refractive index 1·5

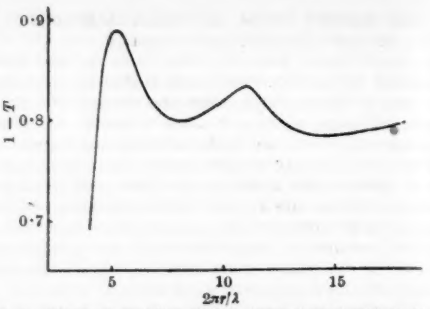


Fig. 2. Observed variation of (1 − transmission) with $2\pi r/\lambda$ for glass spheres of radius 3·5 microns and refractive index 1·5

value of 2 instead of 1; this value is constant for all wave-lengths small compared with the sphere.

In the intermediate region *B*, the Mie theory shows several peaks. These again could be expected qualitatively, since the particle size is here comparable with the wave-length, and resonances might occur, the fundamental being presumably the strongest. It is well known that in resonance the resonator effectively absorbs and re-emits radiation from a cross-section which may be several times its geometrical cross-section, and since the re-emission occurs in all directions, nearly all this radiation is effectively diverted from its original direction. The effective cross-section might therefore be expected to reach maxima at a series of values corresponding to the resonances, giving the form of curve predicted by the Mie theory. This form of curve is confirmed by observations on the scattering of infra-red radiation by small glass spheres[4]. Fig. 2 shows a typical observed curve for glass spheres of diameter 7 microns. The transmission of a screen consisting of a monolayer of many separate particles was actually observed; and (1 − transmission), which should be directly proportional to the extinction produced by a single particle, was plotted against $2\pi r/\lambda$.

The form of the intermediate region in Fig. 1 will account for the blue sun. Wherever the extinction curve is rising, light of longer wave-length will be scattered less than that of shorter wave-length, as in Rayleigh scattering; but wherever the extinction curve is falling, the opposite will be true. In order, therefore, for red light from the sun to be scattered more than blue light, the atmosphere must contain a large number of particles of greater size than usual, and those particles must be grouped in a narrow size-range, corresponding to such a region as *bb'*. A typical diameter would be 1·7 microns for particles of refractive index 1·3, and 1 micron for refractive index 1·5. Such conditions occur only rarely and require either a large-scale liberation of uniform particles of suitable size into the atmosphere, or (more probably) the separation by some atmospheric process of particles in the suitable size-range from a cloud of particles of random size. A corollary to the blue sun is that the sky might at the same time appear pink instead of blue.

William Paul
R. V. Jones

Department of Natural Philosophy,
University of Aberdeen. July 30. [See also p. 545.]

[1] Mie, G., *Ann. Phys.*, **4**, 25, 377 (1908).
[2] Van de Hulst, H. C., "Recherches Astr. de l'Observ. d'Utrecht", **11**, Pts. 1 and 2 (1946).
[3] Walton, W. H., Inst. of Chem. Eng. and Soc. Chem. Indust. Symposium on Particle Size Analysis, 141 (1947).
[4] Paul, W., and Jones, R. V., *Research*, **3**, 98 (1950).

An Accurate Determination of the Positions of Four Radio Stars

THE use of an interferometer aerial system on a wave-length of 3·7 m. to measure the positions of a number of radio stars has already been described[1]. The present communication contains the results of recent more accurate determinations of the positions of four intense radio stars with this interferometer, together with results for the same stars obtained by using another interferometer the individual aerials of which employ parabolic reflectors. This latter interferometer has been used at wave-lengths of 3·7 m. and 1·4 m.

With the new interferometer, it is possible to determine the 'collimation error' either by the interchange of the individual interferometer aerial elements, or by observations of both upper and lower culmination of the circumpolar star 23·01 [1]. In addition, the electrical centres of the aerials are defined more precisely than those of the broadside arrays originally used at 3·7 m.

Declination has been determined from the periodicity of the record, as in the previous observations, and also by two new independent methods. In the first method the times of transit of the star across two 'collimation planes' displaced on either side of the axial plane of the interferometer are determined: the interval between these times is related to the declination. These displaced collimation planes are produced by increasing the electrical path to one or other of the aerials. In the second method, the time-interval between the transits at the upper and lower culminations of a circumpolar star provides a measure of the declination, since the axis of the interferometer is inclined at a considerable angle to the east–west line. The collimation error must here be determined by interchanging the interferometer aerials. A more detailed account of these and other methods of position-finding will be published elsewhere.

Table 1 gives the positions of the four stars, with their probable errors, as determined from the time of transit and the periodicity of the record obtained with the three interferometer systems. It also shows results obtained by the two new methods, which have been used at 1·4 m. Allowance has been made for atmospheric refraction. The co-ordinates refer to the epoch of 1950.

It has been pointed out[1] that, in addition to the instrumental errors, the position may be in error due to the radiation from other nearby weaker stars. It can be shown that, in the present observations, this factor is unlikely to cause an error greater than ½ sec. in the R.A. of the stars 19·01 and 23·01, or greater than about 2 sec. in the R.A. of the less-intense stars 05·01 and 12·01.

The final positions are given in Table 2.

Table 1

Star	Constellation	Wave-length and method	Right Ascension	Declination
			h. m. s.	
05·01	Taurus	3·7 m., broadside	05 31 35 ±5	22° 05′ ±40′
		3·7 m., paraboloid	05 31 35 ±5	22° 11′ ±20′
		1·4 m., paraboloid	05 31 34·5±2	22° 09′ ±5′
		1·4 m., displaced collimation plane	— — —	22° 01′ ±3′
12·01	Virgo	3·7 m., broadside	12 28 17 ±5	12° 50′ ±1°
		3·7 m., paraboloid	12 28 18 ±5	12° 46′ ±20′
		1·4 m., paraboloid	12 28 18·8±2	12° 33′ ±15′
		1·4 m., displaced collimation plane	— — —	12° 31′ ±15′
19·01	Cygnus	3·7 m., broadside	19 57 45 ±5	40° 37′ ±5′
		3·7 m., paraboloid	19 57 45 ±5	40° 32′ ±5′
		1·4 m., paraboloid	19 57 45·3±1	40° 34·5 ±1′
		1·4 m., displaced collimation plane	— — —	40° 35·3′±0·7′
23·01	Cassiopeia	3·7 m., broadside	23 21 13 ±5	58° 30′ ±3′
		3·7 m., paraboloid	23 21 12 ±3	58° 32′ ±2′
		1·4 m., paraboloid	23 21 12·0±1	58° 32·1′±0·7′
		1·4 m., displaced collimation plane	— — —	58° 32·9′±0·5′
		1·4 m., double transit	— — —	58° 30′ ±3′

Table 2

Star	Constellation	Right Ascension	Declination
		h. m. s.	
05·01	Taurus	05 31 34·5±3	22° 04′ ±5′
12·01	Virgo	12 28 18 ±3	12° 37′ ±10′
19·01	Cygnus	19 57 45·3±1	40° 35·0′±1′
23·01	Cassiopeia	23 21 12·0±1	58° 32·1′±0·7′

This work was carried out at the Cavendish Laboratory as part of a programme of radio research supported by the Department of Scientific and Industrial Research. Thanks are due to Mr. M. Ryle for his most valuable advice and help, and to Mr. J. E. Jackson of the Department of Geography for assistance in surveying the positions of the aerials of the new interferometer.

F. G. SMITH

Cavendish Laboratory,
Cambridge.
Aug. 6.

[1] Ryle, M., Smith, F. G., and Elsmore, B., *Mon. Not. Roy. Astro. Soc.*, **110**, 508 (1950).

A Search for Long-Period Variations in the Intensity of Radio Stars

CERTAIN classes of visible star are characterized by well-marked variations of intensity; the period of these variations may be as short as a few hours, or as long as several hundred days. In this communication an account is given of an investigation which has been made to determine whether any of the known radio stars exhibit similar variations of intensity.

The present observations were made on a wave-length of 3·7 m. with an interferometer aerial which has already been described[1]. This system employs two fixed aerials, each of which has a large aperture in an east–west direction and a small aperture in a north–south direction; the interferometer is therefore receptive in a narrow strip which extends along the meridian from about declination + 10° to declination + 80°. Daily observations can therefore be made of radio stars situated throughout most of the northern hemisphere. The number of radio stars which can be distinguished is limited by confusion between the traces produced by adjacent stars and not by the random fluctuations on the record. Thus, although it is only possible to locate about fifty of the most intense radio stars, other sections of the record show well-defined periodic traces due to the simultaneous reception of the radiation from two or three weaker stars. It is not possible to deduce the absolute intensity or the accurate positions of these weaker sources; but by making a detailed comparison of the records obtained each day, it is possible to detect small variations in their intensity.

Observations have been made with this system nearly every day for more than eighteen months, although records representing about 15 per cent of the total observing time have had to be rejected from the present analysis owing to the occurrence of severe 'scintillation' caused by diffraction in ionospheric irregularities[2]. It was found that, of approximately a hundred radio stars examined, none showed any variation of intensity greater than 10 per cent; a more detailed analysis of some of the more intense ones suggested that their intensity was, in fact, constant to better than 5 per cent; but it is difficult, at this wave-length, to eliminate the effects of residual ionospheric irregularities for variations smaller than this.

It is therefore concluded that none of the radio stars observed varies by more than 0·1 magnitude with any period shorter than about 1,000 days; observations of the more intense stars suggest that their intensities may, in fact, be constant to within 0·05 magnitude.

This result is of interest not only for comparison with the behaviour of visible stars, but also in contrast to the marked day-to-day variations in the intensity of the metre-wave radiation from the sun.

This work forms part of a programme of research which is supported at the Cavendish Laboratory by the Department of Scientific and Industrial Research.

M. Ryle
B. Elsmore

Cavendish Laboratory,
Cambridge.
Aug. 8.

[1] Ryle, M., Smith, F. G., and Elsmore, B., *Mon. Not. Roy. Astro. Soc.*, **110**, 508 (1950).
[2] Ryle, M., and Hewish, A., *Mon. Not. Roy. Astro. Soc.*, **110**, 381 (1950).

Nuclear Spin of Rubidium-86

The nuclear spin I of rubidium-86 has been measured by the atomic beam method using magnetic resonance; a mass spectrometer was employed to select the correct isotope[1]. A pronounced resonance was obtained at a frequency of 2·36 Mc./sec. in a magnetic field of 4·22 gauss, which gives $I = 2$. This value is in agreement with the observed shape of the β-spectrum[2]. The hyperfine structure separation was found to be 3,900 ± 100 Mc./sec., which means a magnetic moment of 1·66 ± 0·4 nuclear magnetons. The results suggest that the magnetic moment is probably negative and it would then have a value of − 1·68 ± 0·01 nuclear magnetons. It is planned to extend the measurements to obtain a more accurate value of the magnetic moment and definitely establish its sign.

The rubidium-86 was prepared by the $^{88}Sr\ (d,\alpha)\ ^{86}Rb$ reaction. I wish to thank the Physics Department of the University of Birmingham for carrying out this bombardment, and Dr. A. G. Maddock, of the Radiochemistry Laboratory, Cambridge, for the chemical separation of the rubidium-86.

E. H. Bellamy

Cavendish Laboratory,
Cambridge.
Aug. 16.

[1] Davis, Nagle and Zacharias, *Phys. Rev.*, **76**, 1068 (1949).
[2] Zaffarano, Kern and Mitchell, *Phys. Rev.*, **74**, 682 (1948).

Scattering of 146-MeV. Protons by Deuterons

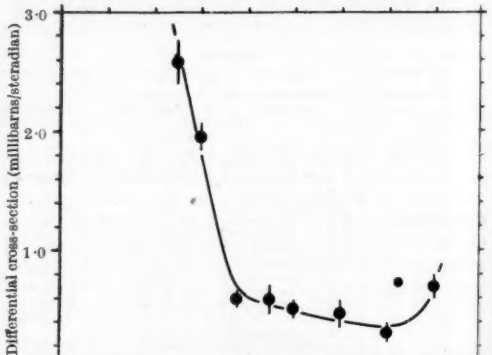
The proton beam and the counting apparatus described in an earlier communication[1] have now been used for a study of elastic proton–deuteron scattering. The results are shown in the accompanying graph.

The scatterer was a rectangular strip of heavy water contained in a capsule made of thin aluminium sheet. Elastic proton–deuteron collisions were observed by detecting in coincidence both the scattered protons and the corresponding recoil deuterons. When the angle of scattering was less than 67° or greater than 85°, the geometry of the arrangement left no doubt as to which counter was detecting the protons in these events. Between these two angles it was not practicable to determine the cross-section except at 76°, where the recoil angles of the two particles are actually equal.

Various background effects were subtracted with the help of a second scatterer filled with normal water. Proton–proton collisions in the hydrogen content of the normal water were not counted, again because of the geometry of the arrangement. All background effects should have been unchanged by the substitution of normal for heavy water, with the exception of that due to inelastic proton–deuteron scattering followed by the detection of both protons. There are three final particles involved in this process, so that the recoil angles of the two protons are not uniquely connected. A consideration of the solid angle subtended by the counters suggested that this source of background could be neglected, and this conclusion was supported by an experiment in which the geometry of the detectors was varied.

The uncertainties shown in the graph are the statistical errors in the determination of the relative values at different angles; it is considered that systematic errors were small in comparison with these. The absolute cross-section was fixed by observing proton–proton scattering with the same apparatus, the cross-section for that process being taken[1] as 4·99 ± 0·31 millibarns. The absolute calibration of the proton–deuteron experiment is subject to an overall standard deviation of 7·8 per cent.

It is hoped to improve the accuracy of these results and later to obtain some information about neutron–deuteron scattering at the same energy. A



Differential scattering cross-section for the scattering of 146-MeV. protons by deuterons, as a function of angle in the centre of mass system

comparison of the two effects should show whether, apart from the Coulomb repulsion, the proton-proton and the neutron–neutron interactions are the same at high energies. The recently published results of Stern and Bloom[2] on the scattering of 190-MeV. deuterons by protons (equivalent to the scattering of protons of approximately 95 MeV. by deuterons) are of great interest from this point of view. If their results are integrated over all angles, an elastic cross-section of roughly 24 millibarns is found. W. M. Powell[3], on the other hand, has observed an elastic neutron–deuteron cross-section of 48 millibarns at 90 MeV. neutron energy.

The experiment reported here was greatly assisted by the co-operation of Mr. A. O. Edmunds and the cyclotron crew. One of us (G. H. S.) is a member of the staff of the South African Council for Scientific and Industrial Research.

J. M. Cassels
G. H. Stafford
T. G. Pickavance
Atomic Energy Research Establishment,
Harwell.
August 24.

[1] Cassels, J. M., Stafford, G. H., and Pickavance, T. G., *Nature*, [168, 468 (1951)].
[2] Stern, M. O., and Bloom, A. L., *Phys. Rev.*, **83**, 178 (1951).
[3] Private communication to R. L. Gluckstern and H. A. Bethe; *Phys. Rev.*, **81**, 761 (1951).

Raman and Infra-Red Spectra of Germanium Tetrafluoride

The Raman spectrum of gaseous germanium tetrafluoride at 1·8 atm. has been investigated with mercury arc excitation, and two lines have been observed. One is excited by λ 4358 and the other by λ 4046 A., the measured Δν-values being 737·1 and 738·4 cm.$^{-1}$ respectively. This shift may with confidence be identified with the symmetrical breathing frequency of the tetrahedral GeF_4 molecule, to which we assign the value $\nu_1 = 738 \pm 2$ cm.$^{-1}$.

We have also observed the infra-red absorption spectrum of gaseous germanium tetrafluoride. This shows several bands, the most intense of which lies at 800 cm.$^{-1}$ and probably corresponds to ν_3.

Further details of the spectra will be published later.

A. D. Caunt
L. N. Short
L. A. Woodward
Inorganic and Physical Chemistry Laboratories,
Oxford.
May 16.

Runs in a Sequence of Observations

In previous communications[1–4] one of us (P. V. K. I.) has discussed a number of distributions arising from m observations belonging to k groups arranged at random on a line. When all the observations are different, m is equal to k, and for this case Kermack and McKendrick[5], and Levene and Wolfowitz[6] have considered the distribution of the number of runs 'up' and 'down'. A run 'up' or 'down' is a succession of observations in ascending or descending order. Kendall[7] has dealt with the same problem by considering the number of 'troughs' and 'peaks'. When m is greater than k, the sequence of observations will have three kinds of runs, namely, ascending, descending and stationary. This note gives the difference equation satisfied by the probability generating function and the first two moments for the distribution of the total number of *junctions* for a sequence of m observations with fixed probabilities $p_1, p_2 \ldots p_k$, a junction being the meeting point between two runs 'up', 'down' or stationary. It may be noted that the total number of runs is equal to the total number of junctions increased by unity.

The difference equation reduces to a $k \times k$ determinant as shown below:

$$\begin{vmatrix} \theta_1 & \psi_{10} & \psi_{11} & \psi_{12} & \cdot & \psi_{1,k-2} \\ \lambda_{20} & \theta_2 & \psi_{20} & \psi_{21} & \cdot & \psi_{2,k-3} \\ \lambda_{31} & \lambda_{30} & \theta_3 & \psi_{30} & \cdot & \psi_{3,k-4} \\ \lambda_{42} & \lambda_{41} & \lambda_{40} & \theta_4 & \cdot & \psi_{4,k-5} \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \lambda_{k,k-2} & \lambda_{k,k-3} & \lambda_{k,k-4} & \lambda_{k,k-5} & \cdot & \theta_k \end{vmatrix} \varphi(m-2) = 0$$

where $\theta_r = E^2 - p_r(p_r + q_r t)$; $\psi_{rs} = -p_r[p_{r+1} + p_{r+2} + \ldots + p_{r+s} + (1 - p_{r+1} - p_{r+2} - \ldots - p_{r+s})t]$ $\lambda_{rs} = -p_r[p_{r-1} + p_{r-2} + \ldots + p_{r-s} + (1 - p_{r-1} - p_{r-2} - \ldots - p_{r-s})t]$; $p_r + q_r = 1$; E is the usual operator in finite difference and

$$\varphi(m) = p(m,0) + p(m,1)\,t + p(m,2)\,t^2 + \ldots,$$

$p(m,r)$ being the probability for r junctions in m observations.

The first two moments are:

$$\mu'_1 = (n-2)\{4\Sigma p_r p_s p_t + 3\Sigma p_r p_s (p_r + p_s)\} = (n-2)P_1(3),$$

$$\mu_2 = \mu'_1 + 2(n-3)\{10\Sigma p_r p_s p_t p_u + 8\Sigma p_r p_s p_t (p_r + p_s + p_t) + 6\Sigma p_r^2 p_s^2 + 2\Sigma p_r p_s (p_r^2 + p_s^2)\} + 2(n-4)\{54\Sigma p_r p_s p_t p_u p_v + 34\Sigma p_r p_s p_t p_u (p_r + p_s + p_t + p_u) + 2\Sigma p_r p_s p_t p_u (p_s + p_t) + 22\Sigma p_r p_s p_t (p_r p_s + p_s p_t + p_r p_t) + \Sigma p_r p_s p_t (p_r p_s + p_s p_t) + 12\Sigma p_r p_s p_t (p_r^2 + p_s^2 + p_t^2) + 2\Sigma p_r p_s p_t (p_r^2 + p_t^2) + 8\Sigma p_r^2 p_s^2 (p_r + p_s) + \Sigma p_r p_s (p_r^3 + p_s^3)\} - (5m - 16)[P_1(3)]^2,$$

$$r > s > t > u > v.$$

The moments for the case when $n_1, n_2, \ldots n_k$ observations belong to k different groups are obtained by substituting

$$\frac{n_r^{(\alpha)} n_s^{(\beta)} n_t^{(\gamma)} \ldots}{n^{(\alpha+\beta+\gamma \ldots)}} \text{ for } p_r^{\alpha}\, p_s^{\beta}\, p_t^{\gamma} \ldots$$

in the moments about the *origin* for fixed p's.

The above moments have been obtained by extending the methods developed by one of us[3,4], by forming the frequencies for three, four and five observations for all possible combinations of equal and unequal observations.

It can be established from the difference equation that all the cumulants of the distribution are linear functions in m, and hence the distribution tends to the normal form as $m \to \infty$. Full details of this work will be published in the *Journal of the Indian Society of Agricultural Statistics*.

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Metallic Oxides with the Structure of High-speed Steel Carbide

Oxides isomorphous with the high-speed steel carbide Fe_3W_3C have been found to exist with the ideal composition Me_3Ti_3O, where *Me* is one of the transition metals manganese, iron, cobalt, nickel or copper (but *not* vanadium, chromium or zinc).

The best agreement between calculated and observed $p\,|\,F\,|^2$ values for powder photograph reflexions and the best space distribution in the cubic unit cell is obtained if the 112 atoms are placed in the following positions of the space group $O_h^7 - Fd3m$:

16 O in 16 : (*c*) 1/8, 1/8, 1/8;
16 *Me* in 16 : (*d*) 5/8, 5/8, 5/8;
32 *Me* in 32 : (*e*) x, x, x ; ($x_e = -0{\cdot}165$)
48 Ti in 48 : (*f*) x, 0, 0 ; ($x_f = 0{\cdot}185$)

Analysis of powder photographs taken with oxides of different compositions gives the probable lower and upper phase limits for the titanium content as Me_3Ti_3O and Me_3Ti_4O respectively. At the latter composition 16 titanium atoms and 16 *Me* atoms are randomly distributed in 32 : (*e*). In comparison, 16 iron atoms take up the positions of 16 tungsten atoms in 48 : (*f*) in high-speed steel carbide of the composition Fe_4W_2C. The following values for the length of the unit cube edge have been found:

Me	Titanium-poor limit	Titanium-rich limit
Mn	11·10 A.	11·28 A.
Fe	11·14	11·31
Co	11·16	11·32
Ni	11·18	11·37
Cu	11·24	11·44

All the new oxides have metallic properties. It is of interest that the titanium atoms, independent of the composition, are surrounded octahedrally by six oxygen atoms.

A detailed report will appear shortly elsewhere.

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Source of Moulting Hormone in *Rhodnius*

The immediate source of the hormone which induces moulting in the larvæ and pupæ of Lepidoptera is the prothoracic gland[1]. But this gland is itself activated by a secretion from neuro-secretory cells in the dorsum of the brain[2]. It has seemed probable for some time that a similar two-stage control of moulting might exist in other insects[3]; and recently it has been found by Possompès[4] that the lateral cells of the ring gland in the larvæ of Diptera are induced to secrete the pupation hormone by a factor liberated from the brain.

It has now been shown that the same sequence of events occurs in *Rhodnius*. Fourth-stage larvæ of *Rhodnius* decapitated at 24 hr. after feeding can be induced to moult by implanting into the abdomen the dorsal region of the brain from larvæ that have just passed the 'critical period'[5]. In the present series, this experiment succeeded in 80 per cent of cases. But if the recently fed larva is ligatured behind the mesothorax and the same implants are made into the isolated abdomen, this fails to moult. There were no positive results in twenty-three experiments.

Search in the thorax has revealed the presence of two strands of large cells, with enormous lobulated nuclei, deeply imbedded in the fat body and extending throughout the prothorax and mesothorax. These cells are abundantly supplied with tracheoles. They undergo a cycle of development in each moult, increasing greatly in size at the 'critical period', becoming small again at the end of the moulting stage. They break down and disappear in the adult within forty-eight hours after moulting.

If these cells are removed from a larva that has just passed the critical period and are implanted into the abdomen of a larva decapitated at 24 hr. after feeding, this is caused to moult (six positive in eighteen experiments). If they are implanted into recently fed larvæ ligatured through the metathorax, the isolated abdomen is likewise caused to moult (seven positive among thirteen survivors).

Similarly, the adult *Rhodnius* is not caused to moult by implantation of the brain; but moulting is induced if the thoracic gland from the moulting fifth-stage larva is implanted.

A corresponding gland has been found also in *Nepa*, where it likewise disappears in the adult insect.

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Activation and the Correlation between Male and Female Elements in Fertilization

In the course of investigations on the process of fertilization, immature rats, which had been allowed to mate, were killed shortly after induced ovulation. Thirty-six animals yielded 477 eggs in the early phase of fertilization. The correlation in the stages shown by the male and female elements in the living eggs was carefully examined with the aid of the phase-contrast microscope. The stages were classified as follows: for the male element, (*a*) sperm present in the perivitelline space, (*b*) sperm in the vitellus but with head unchanged, (*c*) sperm head changing, (*d*) male pronucleus forming; for the female element, (*a*) chromosomes in metaphase of second maturation division, (*b*) in anaphase, (*c*) in telophase, (*d*) polar body abstricted, (*e*) female pronucleus forming. The numbers of eggs showing these stages are recorded in the accompanying table.

Of the 108 eggs which contained sperms only in the perivitelline space, the great majority (103) displayed chromosomes arranged in metaphase. In the

Correlation between Male and Female Elements during Early Stages of Fertilization in 477 Rat Eggs

Male \ Female	Chromosomes in metaphase	Chromosomes in anaphase	Chromosomes in telophase	Polar body formed	Pronucleus forming
Sperm in perivitelline space	103	1	1	3	
Sperm in vitellus, unchanged	4	8	6	1	
Sperm in vitellus, head changing		5	47	173	1
Pronucleus forming				47	77

remaining five eggs, however, the mitosis had proceeded and in three of them the polar body had been formed. These five eggs thus exhibited signs of activation although no sperm had yet entered the vitellus.

Only nineteen eggs were observed in which there was an unchanged sperm within the vitellus. The infrequency of the observations connotes the brevity of this state. Most (fifteen) of these eggs showed signs of activation, including one in which the second polar body was visible. In the remaining four eggs sperm entry probably occurred just before the eggs were obtained for study; but some delay of activation is here indicated.

In 226 eggs the head of the penetrating sperm showed distinct changes, and in the majority (173) the second polar body had been formed. Some eggs (47), however, had chromosomes still in the telophase condition. In this series also there were indications both of early activation (one egg) and delayed activation (five eggs).

Finally, 124 eggs were observed showing the early stages of formation of the male pronucleus. The larger proportion (77) of these showed also the early female pronucleus; but the remainder (47) carried egg chromosomes still in the form seen after polar body formation.

Another group of immature rats was killed at a later stage, between 16 and 26 hr. after ovulation. Among these were 57 animals which yielded 228 eggs showing the various stages involved in the reappearance of the chromosomes and the formation and division of the first segmentation spindle. In none of these eggs was there any indication of a lack of correspondence between the male and female elements.

From these observations the following conclusions are drawn. There is a fairly close correlation between the male and female elements in the early phase of fertilization of the rat's egg. While the sperm is in the perivitelline space, the egg chromosomes are nearly always in metaphase. After the sperm has entered the vitellus, but before it has undergone perceptible change, the egg chromosomes are mostly seen in anaphase or telophase. The mitosis evidently proceeds very shortly after sperm entry. Soon the sperm head shows changes in form, and by the time these have become distinct the polar body is abstricted. Nearly always the early form of the male pronucleus appears before the female (47 eggs had only the male pronucleus; only one egg had solely the female pronucleus).

Activation of the egg may occur before the sperm has entered the vitellus, though the sperm head may possibly have broken the continuity of the vitelline surface. On the other hand, activation may occasionally be a little delayed. For these reasons the correlation seen in the early stage of fertilization is incomplete. Later, however, a closer correspondence is observed and is especially evident at the stages immediately preceding segmentation. Apparently a co-ordinating influence in the egg becomes effective in the course of fertilization.

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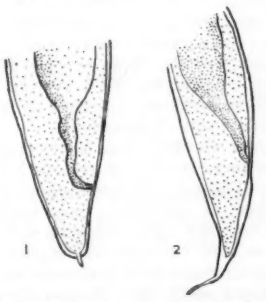
A New Species of *Nematodirus* in Sheep

Outbreaks of parasitic disease in lambs have occurred in the north of England during June and July 1951. Deaths have been associated with the presence of large numbers of nematodes of the genus *Nematodirus*. We are grateful to Mr. W. Lyle Stewart, who sent us the contents of the intestines of five lambs which had been sent to him for examination. About two million worms were received, and the collection was remarkable not only because of the large numbers but also because more than 90 per cent of the worms belonged to the genus *Nematodirus*. Examination showed that there were no *N. spathiger*, a large number of *N. filicollis* and a large number of a third species of *Nematodirus*. This last species cannot be referred to any known member of the genus, and it is proposed to name it *Nematodirus battus*. The description is as follows.

Nematodirus battus n.sp. Body attenuated anteriorly. Mouth surrounded by six papillæ. Cephalic cuticle dilated. *Male:* Length 10–13 mm., maximum diameter 0·12–0·13 mm. Bursa with two large lateral lobes; dorsal lobe small. Ventro-ventral and latero-ventral close and parallel; laterals arise from a common trunk, diverging in the distal half; postero-lateral and medio-lateral not parallel; externo-dorsal arises close to the base of the dorsal ray, which is doubled and has bidigitate extremities. Spicules filiform, 0·85–0·95 mm. long; tips united by a membrane; end bluntly pointed. Gubernaculum absent. *Female*: Length 17–22 mm., maximum diameter 0·16–0·22 mm.; vulva in the posterior third of the body. Tail pointed. Eggs large, 195 μ × 95 μ. Host: *Ovis aries*. Location: small intestine.

This species can be distinguished from others of the genus by the fact that the tail of the female is not truncate but finely pointed, and that the bursa of the male has the medio- and postero-laterals divergent and not parallel.



(1) *N. filicollis*, tail of female; (2) *N. battus*, tail of female

A more detailed description will be given elsewhere; but the above description is provided to enable observations to be made during the present outbreak. This species can be most rapidly separated from *N. filicollis* and *N. spathiger* by examination of the tails of female worms (see Figs. 1 and 2), and it is hoped that other workers may contribute information on the distribution and biology of this worm.

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Mytilicola intestinalis, Steuer, in the European Flat Oyster (*Ostrea edulis*)

While examining a sample of ninety-six two- and three-year-old oysters taken from the Penryn River, Cornwall, on June 20 to assess the incidence of Dutch shell disease[1], *Mytilicola intestinalis* was found in three of the oysters. As the main initial interest of the sample lay in the shells, the meats were being discarded without examination. About thirty oysters had been opened and the meats discarded when a slip of the knife resulted in the cutting of the visceral mass; *Mytilicola* was then observed. The remaining sixty-six oyster meats were examined as the oysters were opened; two were found to be infected, but small parasites may have been overlooked.

A further sample of fifty similar oysters was procured from Penryn on June 26. Two *Mytilicola* were found in one oyster. The percentage infection would thus appear to be of the order of 3 per cent.

The infestation was light, the largest number of parasites found in one host being three. The ten parasites found comprised eight females and two males. Two females carried external egg-sacs, another had well-developed internal gonads, and the remainder were immature.

Mussels in the district are heavily infected with *Mytilicola*; but they are not abundant on the grounds from which the oysters were taken.

On July 7 a similar sample of two and three year-old native oysters taken from Tollesbury North Channel, on the north side of the River Blackwater, Essex, was also found to be infected. It was not possible to examine the oysters with the care necessary to detect small parasites; but six oysters out of 111 yielded a total of seven large *Mytilicola*, including two females with external egg-sacs. The parasites lay in the excurrent limb of the intestine, some distance forward from the anus, and could not be seen until the visceral mass was cut. Mussels in the River Blackwater are known to be infected with *Mytilicola*, and the parasite has been established in the vicinity for several years.

So far as is known, these are the first records of the occurrence of this parasite in oysters, but *Mytilicola orientalis*, Mori, has been recorded from *Ostrea lurida* on the Pacific coast of America[2].

It has been shown[3] that heavy infestation with *Mytilicola* is associated with serious loss of condition in mussels. There is the possibility, therefore, that a similar loss of condition may occur in infected oysters. The very light infestation in areas where *Mytilicola* is well established suggests that the infection of oysters requires a special set of conditions which does not occur very frequently in Nature. It is to be noted, however, that the gonads of several of the parasites were mature, and the possibility that *Mytilicola intestinalis* may become adapted to life in oysters cannot be excluded.

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The Leaf Scar as an Avenue of Infection for the Cherry Bacterial Canker Organism, *Pseudomonas mors-prunorum* Wormald

The development of branch cankers from previously infected fruiting spurs was noted by Wormald[1] in his original etiological study of the bacterial canker disease of cherry (*Ps. mors-prunorum*), and later by Webb[2], who concluded that most branch cankers originated in this way. Records made over the past two years during field observations on 5–12 year old cherries of several varieties have confirmed this view. Between 90 and 100 per cent of branch cankers examined, depending on the age and variety of the tree, were around the base of a dead spur. This association, together with the frequent occurrence of dead spurs with incipient cankers at the base and dead spurs without basal cankers, clearly indicated the sequence of infection.

As the fruiting spurs are thus primarily concerned in the initiation of the branch cankers, the mode of entrance of the pathogen into them is therefore highly relevant to the formulation of control measures. Most of the foliage is borne on these spurs, and Montgomery and Moore[3], who effected some control of the canker phase by the autumnal application of Bordeaux mixture sprays, suggested that the spurs become infected through the leaf scars during the autumnal leaf-fall period. This is the only time in the annual cycle of the disease when the condition of winter susceptibility of the stem and branch tissues coincides with the presence of a copious inoculum from the over-summered leaf-spot stage of the disease, and it is therefore the most likely period for infection.

More direct evidence that the leaf scar is an important avenue of infection has now been obtained by experimental inoculation of leaf scars in the autumn. The laminæ of the leaves on selected fruiting spurs were excised in October, thus inducing abscission in the petioles, which were then readily detached after ten days. Spurs with the leaf scars thus exposed were inoculated immediately, and at varying intervals afterwards. No wounds were made, and the inoculum, an aqueous suspension of a 48-hr. culture of *Ps. mors-prunorum*, was applied to the scars with a loop. The results of one experiment, recorded the following May, are summarized in the accompanying table.

Interval between exposure of scar and inoculation	No. of spurs inoculated	No. of spurs killed	No. of killed spurs developing branch cankers
0 days	103	101	40
3 days	102	70	37
8 days	96	32	14
Uninoculated controls	100	0	0

These results are an aggregate for two varieties of cherry, one comparatively resistant and one susceptible to this disease. Approximately the same number of spurs was killed in each; but in the resistant variety only 11 per cent of these led to the formation of branch cankers compared with 63 per cent in the susceptible one. In view of the difficulty frequently encountered of reproducing cankers comparable with natural ones by inoculation through an artificial wound directly into the branch tissues, it is noteworthy that the cankers following inoculations of the leaf scars were indistinguishable in form and severity from those occurring naturally. On the six trees of the susceptible variety, nineteen of the

twenty-four branches bearing inoculated spurs died from cankers which had girdled them by the following May.

Preliminary observation and histological studies suggest that the bacteria enter the spur via the vascular traces of the leaf scar.

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Fusaria Isolated from South Indian Soils

In connexion with work on *Fusarium* wilt of cotton in South India, I took up in 1947 a detailed study of *Fusarium* floras of certain South Indian soils, particularly 'wilt-sick' black cotton soils. Wide occurrence of *Fusaria* in soils has been reported from a number of countries, though no such detailed survey has been undertaken in India. The present work was directed towards determining the different species of *Fusarium* that occur in 'wilt-sick' black cotton soils around Udamalpet (Coimbatore District, Madras State), mainly following the techniques of the traditional *Fusarium* investigations of Wollenweber, Reinking and others[1,2,3].

In the isolation of *Fusaria* from soils, the 'root burial' technique[4] was largely used, supplemented by the dilution-plate technique. In general the former gave a much better picture of the *Fusarium* flora than the latter, since *Fusaria* seldom appeared on dilution plates but could be easily recovered from bits of root initially buried in soils and later removed and plated out on suitable media. The following species of *Fusarium* were isolated from Udamalpet soils

1. *Fusarium avenaceum* (Fr.) Sacc.
2. *F. chlamydosporum* Wr. et Rg.
3. *F. culmorum* (W.G.Sm.) Sacc.
4. *F. equiseti* (Cda.) Sacc.
5. *F. javanicum* Koord.
6. *F. javanicum* Koord. v. *radicicola* Wr.
7. *F. oxysporum* Schlecht.
8. *F. poae* (Peck) Wr.
9. *F. scirpi* Lamb. et Fautr.
10. *F. scirpi* Lamb. et Fautr. v. *acuminatum* (Ell. et Ev.) Wr.
11. *F. solani* (Mart.pr.p.) App. et Wr.
12. *F. solani* (Mart.) v. *Martii* (App. et Wr.) Wr.
13. *F. solani* (Mart.) App. et Wr. v. *minus* Wr.
14. *F. solani* (Mart.) App. et Wr. v. *striatum* (Sherb.) Wr.
15. *F. vasinfectum* Atk.

The importance, from the point of view of plant disease, of the occurrence of different species of *Fusarium* in 'wilt-sick' soils will become obvious when it is realized that considerable evidence has accrued in recent years indicating that some wilts and root rots of crop plants are caused by complex infections by more than one species of *Fusarium*. Details of the present work will be published elsewhere.

I am grateful to Prof. T. S. Sadasivan for much guidance and criticism during the course of the present work. My thanks are due to the National Institute of Sciences of India for the award of an I.C.I. Fellowship, during the tenure of which the major part of the work was carried out.

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Myxobacteria Mistaken for Nitrifying Bacteria

In connexion with the communication under this title by Miss Joyce B. Grace, published in *Nature* of July 21, p. 117, a careful re-reading of Winogradsky's papers on the subject[1] leads me to believe that he has described two quite different species under the name of *Nitrosocystis*. In the first place, there is the organism isolated by Romell[2] from forest soil by Winogradsky's later technique of placing grains of soil on the surface of silica gel plates. Imsenecki repeated this work, and obtained *Nitrosomonas*, and a non-nitrifying myxobacterium, *Sorangium symbioticum*[3]. In the second place, there is the zooglœa-forming species, isolated by Winogradsky from Zurich soil by the enrichment culture technique, originally described in 1892 as a *Nitrosomonas*, and reclassified by Winogradsky in 1933 as a *Nitrosocystis*. This species forms the 'hard colonies' mentioned by Kingma Boltjes[4], whose work Miss Grace dismisses with the statement that there was "no evidence that the cultures were pure"; the cultures in question, however, were single-cell isolations. As regards hard colonies, I have seen them formed by my own pure cultures of an ammonia-oxidizing bacterium, which I have every reason to believe is a *Nitrosomonas*[5]. I think that the formation of hard or soft colonies depends on the density of the silica gel in the plate, and also on whether the colony is buried or superficial; Kingma Boltjes observed both types on his plates made from pure cultures of *Nitrosomonas*.

I would be inclined to think that the first "*Nitrosocystis*" may be a myxobacterium, but that the second is a true nitrifier, so that the genus *Nitrosocystis* is still valid in this sense, unless further work should show it to be identical with *Nitrosomonas*. I do not feel qualified to express an opinion on the genera *Nitrocystis* and *Nitrosoglœa*.

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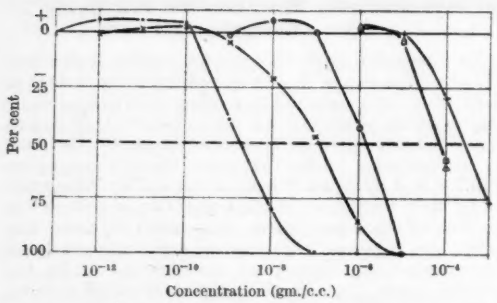
Effect of *cis*-Cinnamic Acid and some Isomeric Compounds on the Germination of Zygotes of *Chlamydomonas*

The effect of a number of organic acids as inhibitors of germination has been tested on the zygotes of the *blastikos* race of *Chlamydomonas eugametos*[1]. It was observed that *trans*-cinnamic acid inhibits germination to about 50 per cent even at a dilution of 10^{-7} gm./c.c. The experiment has now been extended to the three different allotropic modifications of *cis*-cinnamic acid and a few isomeric compounds. The percentage of inhibition of germination with respect to that of control is shown in the accompanying graph. The experimental method and evaluation have been described in greater detail elsewhere[2]. The percentage germination of the control (in *Volvox* solution) is $85{\cdot}92 \pm 0{\cdot}429$ per cent ($n = 1{,}186$ zygotes). The activity of cinnamic aldehyde is very small, since at 10^{-5} gm./c.c. the germination remains unaffected. A similar effect is also



Percentage inhibition of germination with respect to control (0-line): cinnamic aldehyde, △—△; *o*-coumaric acid, □—□; *β*-*d*-glucosido-*o*-coumaric acid, +—+; coumarin, ○—○; *trans*-cinnamic acid, ×—×; *cis*-cinnamic acid, ●—●, tested on the zygotes of the *blastikos* of *Chlamydomonas eugametos*. The concentrations for 50 per cent inhibition can be read from the broken line. + is promotion (above the 0-line)

found in the case of *trans*-2-oxy-cinnamic acid (*o*-coumaric acid). β-*d*-Glucosido-*o*-coumaric acid is less active than the aglucone. Coumarin is a hundred times more active; even at a dilution of 10^{-8} gm./c.c. a statistically significant promotion of germination can be definitely observed. Still more active is *trans*-cinnamic acid as has been already reported[1]; though in very dilute solution (10^{-10} to 10^{-12} gm./c.c.) no statistically significant promotion of germination was recorded. The range of activity of *cis*-cinnamic acid is fifty to eighty times more than that of the *trans* form, since even at a dilution of 10^{-11} to 10^{-12} gm./c.c. a significant promotion of germination could be observed. The three allotropic modifications of *cis*-cinnamic acid (42° C., 58° C., 68° C.) have the same activity[2].

The strong activity of coumarin can be ascribed to the opening of the lactone ring and the formation of *cis*-2-oxy-cinnamic acid (coumarinic acid). As the compound is unstable, its effect could not be tested on zygotes of *Chlamydomonas*. It may be assumed that the activity of *trans*-cinnamic acid is due to the formation of *cis*-cinnamic acid during the germination of zygotes, which takes place only in the presence of light[2]. Then it would be expected that, with a sufficiently large number of zygotes, at a dilution of 10^{-10} to 10^{-11} gm./c.c. of *trans*-cinnamic acid, promotion of germination will be observed. The question of the isolation of natural germination inhibitors from zygotes of *Chlamydomonas* remains still open.

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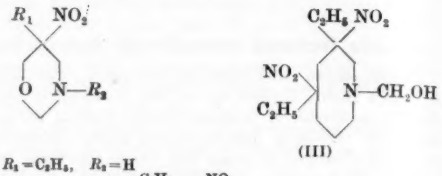
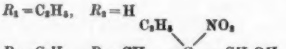
New Derivatives of Nitroparaffins and their Antitubercular and Antirickettsial Properties

As I have indicated earlier, the reaction of nitroparaffins with formaldehyde and ammonia or amines may lead to the formation of polymers[1]. Further experiments have shown[2] that a number of new ring compounds of 1 : 3-tetrahydro-oxazine (I and II) and 1-oxa-3-aza-*cyclo*octane (III) type are formed by the interaction of 1-nitropropane with formaldehyde and ammonia. The products can be transformed into hydrochlorides of the open-chain amines (IV), (V), (VI) or methiodide (VII). 2-Nitropropane yields the amine (VIII)[3] with formaldehyde and ammonia.

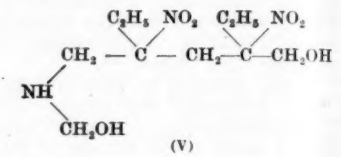
Recently, my co-workers and I isolated the compounds (IX) and (X) from nitroethane[4] and the compound (XI) from phenylnitromethane[5], formaldehyde and ammonia reaction products. Also, an oxazine (XII) was prepared from 1-nitropropane, formaldehyde and methylamine[6].



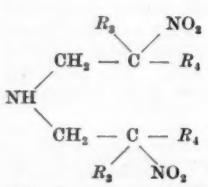
(I) $R_1 = C_2H_5$, $R_2 = H$



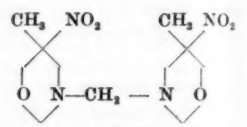
(II) $R_1 = C_2H_5$, $R_2 = CH_2$
(VII) $R_1 = C_2H_5$, $R_2 = (CH_3)_3$ I⊖
(XI) $R_1 = C_6H_5$, $R_2 = CH_2OH$
(XII) $R_1 = C_2H_5$, $R_2 = CH_2$



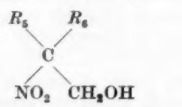
(V)



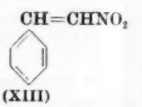
(IV) $R_3 = C_2H_5$, $R_4 = CH_2OH$
(VIII) $R_3 = CH_3$, $R_4 = CH_3$
(IX) $R_3 = CH_3$, $R_4 = CH_2OH$



(X)



(VI) $R_5 = C_2H_5$, $R_6 = CH_2NH_2$
(XIV) $R_5 = CH_3$, $R_6 = CH_2OH$
(XV) $R_5 = C_2H_5$, $R_6 = CH_2OH$
(XVI) $R_5 = CH_3$, $R_6 = CH_3$
(XVII) $R_5 = C_2H_5$, $R_6 = CH_2OH$



(XIII)

All these substances and ω-nitrostyrene (XIII) representing nitroaralkenes and a series of nitro-alcohols deriving from nitroparaffins (XIV), (XV), (XVI) and (XVII) were tested against saprophytic mycobacteria (six strains) *in vitro* in Youman's medium and *in vivo* against *Mycobacterium tuberculosis* ($H_{37}Rv$ strain) in white mice inoculated intravenously. They were also tested *in vivo* against *Rickettsia prowazeki*.

Some of the results of bacteriostatic concentrations *in vitro* are shown in Table 1.

All compounds except (IV) and (XIII) possess a relatively low toxicity. The lethal dose of some of them in rats is given in Table 2[5].

On the basis of these experiments, a few compounds were selected for testing *in vivo* in white mice. The results are shown in Table 3.

Table 1[7]

Substance	I	IV	V	VI	VIII	IX	XII	XIII	XIV	XV	XVII
Bacteriostatic concentrations (mgm. per 100 ml.)	7·5–125	7·5–60	7·5–60	30–60	15–125	15–30	7·5–30	5–15	30–125	30–60	30–60

(The wide range of concentrations was produced by examining the action on different strains.) Substances (VII) and (XVI) were found to be inactive.

Table 2

Substance	Lethal dose (gm. per kgm. of body-weight of rats) Intravenous	Subcutaneous	*per os*
I	0·6	1·5	
II	—	2·6 (in oil)	*c.* 3·0
III	—	—	*c.* 3·0
IV	0·2	—	
V	0·7	2·0	
VI	1·1	—	
VIII	0·3	—	
IX	0·8	1·2	
X	—	—	*c.* 3·0
XII	0·6	1·8	
XIII	—	0·15 (in oil)	0·6
XIV	—	3·5	
XV	—	1·0	
XVII	0·3	—	

After 35 days, all survivors were killed and the extent of tuberculous involvement was noted and rated. Experiments with the substances (I), (V), (VI), (X) and (XIV) are being continued.

Substances (XII) and (XV) were also examined as to their action *in vivo* against *Rickettsia prowazeki*. They proved to be more efficient than *p*-aminobenzoic acid[8]. Inoculated white mice treated with (XII) or (XV) lived for nine days; those treated with *p*-aminobenzoic acid survived four to six days; controls died after three to four days.

Identification of a Heparin as a Main Component of the 'Third Factor' involved in the Virulence-enhancing Action of Hog Gastric Mucin

PREVIOUS work[1–4] has shown that the virulence-enhancing action of hog gastric mucin is due to a synergic action between two non-specific factors (a viscous medium and particulate residue), and a more specific soluble third factor. Partial purification of the latter[3] yielded a heterogeneous product which was predominantly peptide in nature, but which contained 5–10 per cent of carbohydrate residues. Further purification, using a revised assay[4] in which the two non-specific factors are maintained constant, has shown that the carbohydrate moiety is responsible for the activity.

After much preliminary fractionation of the crude mucin from fresh hog gastric mucosæ, this moiety was separated into two active fractions by using the different solubilities of their barium salts in water and in aqueous alcohol. Fraction *A* is precipitated from aqueous solution by adding 3 per cent barium acetate at *p*H 7 and standing at 0° for several days. It has been obtained as an amorphous sodium salt, and examination at *p*H 4·5 and *p*H 8·0 by ultra-

Table 3[7]

Substance	No. of animals	Daily dose (mgm.) per mouse	Administration	Number of days of administration	Mortality after 35 days	Average tuberc. index	Average survival time
Streptomycin	15	10	subcut.	30	0	22	35
I	15	10	*per os*	30	6·6%	44	32·5
II	15	10	,,	30	60·0%	86	31·5
III	15	10	,,	30	53·3%	72	30·2
V	15	10	,,	20	28·5%	75	32·5
X	15	10	,,	30	40·0%	71	32·0
XII	15	10	,,	28	57·4%	83	31·1
XIV	15	10	,,	30	33·3%	77	31·2
XV	15	10	,,	30	80·0%	94	31·9
Control	15	—	—	—	73·3%	100	28·6

I am much indebted to Prof. S. Ślopek, of the Silesian Medical Academy, for carrying out the *in vitro* and *in vivo* experiments, and Dr. J. Venulet, of the Medical Academy, Warsaw, for examining the toxicity of the substances.

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centrifugation and electrophoresis indicates a single homogeneous substance. A typical batch has an activity of 3·9 (2·9–5·1) virulence-enhancing units[4]. Fraction *B* is soluble in aqueous solution containing 3 per cent barium acetate and is precipitated by adding alcohol to 50 per cent v/v. It contains no ester sulphate or hexuronic acid detectable by the Dische carbazole reaction[5], and is still impure, but it is predominantly carbohydrate, containing a high proportion of hexosamine. A typical batch has an activity of 1·1 (0·7–1·8) virulence-enhancing units[4]. Purification of this compound is being continued.

Active heparins are mucoitin sulphuric esters in which the number of sulphate groups can vary considerably[6]. Chemical analysis of the essentially homogeneous fraction *A* clearly indicates that it is a heparin. This has been further confirmed by comparing the anticoagulation activity of fraction *A* with that of three different, highly active, samples of authentic heparin which were also assayed for virulence-enhancing activity. In addition, my colleague Dr. H. P. Lambert had found that fraction *A* inhibits

Table 1. Analytical Figures on Fraction *A* on the Neutral Sodium Salt of Heparin and those Calculated for a Mucoitin Disulphuric Ester

	Fraction *A*	Heparin			Calc. for mucoitin disulphuric ester	
		Reinert and Winterstein (ref. 8)	Wolfrom *et al.* (ref. 9)			
	Mixture of neutral and acid sodium salt	Neutral sodium salt ex. crystalline barium salt	'Roche' heparin neutral sodium salt	Neutral sodium salt ex. crystalline barium salt	Neutral salt $C_{12}H_{14}O_{14}NS_2Na_3$	Acid salt $C_{12}H_{17}O_{14}NS_2Na_2$
C	25·3	23·4	—	—	25·6	26·6
H	3·7	3·5	—	—	2·84	3·16
N	2·49(*D*) 2·75(*Kj*)	2·6	2·6	—	2·49	2·59
S	11·7	11·9	11·7	—	11·3	11·8
Na (from sulphated ash)	10·5	11·6	12·0	12·4	12·2	8·5
P	Nil	Nil	0·1	—	Nil	Nil
Anhydrohexosamine					28·5	29·7
(1) Elson and Morgan (ref. 11) after 3*N* or 4*N* HCl hydrolysis	22·7	—	22·2	21·4		
(2) Van Slyke after 3*N* HCl hydrolysis	27·0	—	—	—		
Anhydrohexuronic acid					31·2	32·5
(*a*) Lefèvre and Tollens	24·1	—	22·2	—		
(*b*) Dische (ref. 5)	31·4	—	—	—		
α (20–25° *C.*; L in water)	+ 53° (*C* = 1)	+ 45° (*C* = 1 corrected for 6·9 per cent water)	+ 42° (*C* = 2)	+ 55° (*C* = 2)		

Table 2. Anti-coagulation Test on the Fraction *A* and Three Different Heparin Samples

Strength % w/v of anti-coagulant solution	Mgm. anticoagulant per 100 ml. blood	Time for complete coagulation in hours							
		Fraction *A*		Boots heparin		Evans heparin		Roche heparin	
		Test 1	Test 2	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2
0·0156	1·25	No clot	96	84	84	24	36	48	36
0·0125	1·0	No clot	48	24	36	18	36	48	36
0·00625	0·5	4	5	5	4	2·5	5	9	4
0·00313	0·25	2	2	1·25	1·25	1·25	1·25	2	1·5
0·00156	0·125	1	1	0·5	0·5	0·5	0·5	0·75	1·25
Nil	Nil (saline control)	0·25		0·25		0·3		0·3	

sheep-cell hæmolysis, and that this effect is due to an anti-complementary action. Heparin has already been shown to be anti-complementary[7].

Table 1 shows the more important analytical figures for fraction *A*, the slightly acid reaction (*p*H 5·5–6·0) of which indicates that the final dialysis, to remove sodium sulphate after decomposition of the barium salt at *p*H 7, has resulted in a loss of sodium ions and produced a mixture of acid and neutral salts. Figures published by Reinert and Winterstein[8], and Wolfrom *et al.*[9] for the neutral sodium salt of heparin, are included in the table, together with those calculated for an average polymer unit composed of a mucoitin disulphuric ester. Other relevant experimental data for fraction *A* which have already been found true for heparin are the absence of acetyl groups detectable by *p*-toluene sulphonic acid hydrolysis[9,10], a Van Slyke amino-nitrogen figure which increases with reaction time[9], the wide discrepancy between the Dische and Tollens–Lefèvre methods of estimating hexuronic acid[5], the presence of *d*-glucosamine[9] as detected by paper chromatography, the presence of a free carboxyl group[9], and the crystallization of an acid barium salt in micro-sheaves[9].

Table 2 shows a comparison of the anticoagulation activity of fraction *A* with that of three different, highly active samples of heparin from Boots Pure Drug Co., Ltd. (102 I.U. per mgm.), Evans, Lescher and Webb (93 I.U. per mgm.) and Roche Products, Ltd. (120 I.U. per mgm.). Fresh ox blood (3·75 ml.) was mixed with solutions (0·3 ml.) of different strengths of the samples under test, and the time for complete coagulation was noted using the technique described by Jorpes[12,13]. These results show that fraction *A* has a slightly greater activity than that of the three authentic heparin samples. Corresponding virulence-enhancing activities, when determined by the assay used for the third factor involved in virulence enhancement, are, in the usual units: fraction *A* 3·9 (2·9–5·1); Boots heparin, 3·2 (2·1–4·8); Evans, Lescher and Webb heparin, 2·2 (1·4–3·3); Roche heparin, 3·5 (2·3–5·1). Adequate controls ruled out any possible toxicity of these samples at the concentrations used for the test.

Full details of this work will be published elsewhere. Acknowledgment is made to the Chief Scientist, Ministry of Supply, for permission to publish this communication.

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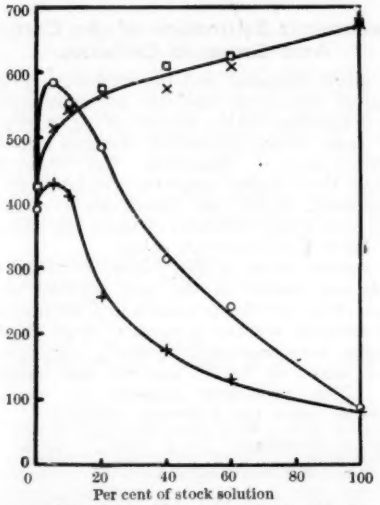
Quaternary Detergents and the Activity of Trypsin and Plasmin

DURING investigations on antiproteolytic substances an interesting action of two quaternary surface-active agents, namely, cetylpyridinium chloride ('Germidin', Bionova, Ltd., Copenhagen) and lauryl-benzyldimethylammonium chloride ('Rodalon', Ferrosan, Ltd., Copenhagen), was observed.

Mixtures of the quaternary compounds with trypsin (Armour, crystalline, containing not more than 50 per cent magnesium sulphate) and plasmin (human, streptokinase-activated) were tested for fibrinolytic activity by means of the plate method[1,2]. The results are presented in the accompanying graph.



□—□—, Trypsin + 'Rodalon'; ×—×—, trypsin + 'Germidin'; O—O—, plasmin + 'Rodalon'; + — +, plasmin + 'Germidin'

Action of cetylpyridinium chloride ('Germidin', 1 per cent stock solution) and lauryl-benzyldimethylammonium chloride ('Rodalon', 1 per cent stock solution) on the fibrinolytic activity of equal volumes of enzyme solution. *Abscissa:* Concentration of quaternary compound added in per cent of stock solution. *Ordinate:* Fibrinolytic activity recorded as the product of two diameters of the lysed zones

It is seen that the fibrinolytic activity of trypsin is increased considerably by the addition of the quaternary compounds. Plasmin shows an increase in activity in the presence of very small concentrations of the compounds, while larger amounts inhibit. These results stress the difference between trypsin and plasmin as proteolytic enzymes. Chymotrypsin (Armour, crystalline, 50 per cent magnesium sulphate) was slightly inhibited. An *Aspergillus* protease[3] (courtesy of Dr. W. G. Crewther, Melbourne) was activated slightly.

Our experiments have shown that proteolytic enzymes may be characterized and grouped according to the influence of a number of antiproteolytic substances. These investigations will be published in detail elsewhere.

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Effect of Temperature on the R_F Values of the Amino-acids during Paper Chromatography with Solvents completely Miscible with Water

CONSDEN *et al.*[1] observed that in the case of phenol saturated with water as the developing solvent, R_F values of amino-acids increase with increase of temperature, since the water-content of phenol varies directly with temperature within the range studied. The reverse is the case with collidine, the water-content of which decreases with increase of temperature. The water-content of solvents which are completely miscible with water can be suitably adjusted, the phase-composition remaining unaffected by temperature. If the change in phase-composition of the developing solvent is the only cause of alterations of R_F values with temperature, they should be independent of temperature in case of miscible solvents. That this is not so will be clear from the following.

The miscible solvents employed were pyridine, acetone and *iso*propyl alcohol. Since these solvents are highly volatile, the ascending method[2] of paper chromatography was followed, using throughout Whatman No. 1 filter paper. The positions of the amino-acids on the chromatogram were, as usual, indicated with ninhydrin. The range of variation in temperature during a particular experiment did not exceed half a degree. The accompanying table records the R_F values at different temperatures of four amino-acids out of a large number I have investigated.

Developing solvent	Amino-acids	R_F values at 16° C.	15° C.	20° C.	25° C.	30° C.
Acetone–water (7 : 3 by vol.)	Aspartic acid	0·23	0·31	0·38	0·53	0·58
	Glycine	0·26	0·34	0·36	0·51	0·51
	Proline	0·46	0·49	0·51	0·65	0·69
	Phenylalanine	0·53	0·63	0·64	0·72	0·72
Pyridine–water (7 : 3 by vol.)	Aspartic acid	0·25	0·27	0·33	0·25	0·32
	Glycine	0·34	0·35	0·38	0·36	0·36
	Proline	0·51	0·56	0·60	0·55	0·52
	Phenylalanine	0·63	0·70	0·71	0·72	0·68
*Iso*propyl alcohol–water (7 : 3 by vol.)	Aspartic acid	0·12	0·13	0·17	0·28	0·17
	Glycine	0·20	0·23	0·27	0·30	0·26
	Proline	0·32	0·40	0·45	0·47	0·44
	Phenylalanine	0·47	0·51	0·56	0·57	0·55
*Iso*propyl alcohol–water (9 : 1 by vol.)	Aspartic acid	0	0	0	0	0
	Glycine	0·02	0·02	0·03	0·04	0·05
	Proline	0·10	0·11	0·11	0·13	0·15
	Phenylalanine	0·17	0·18	0·19	0·20	0·25

These results indicate that in most cases the R_F values increase with rise of temperature, except in the case of pyridine–water at 25° C. and *iso*propyl alcohol–water (7 : 3) at 30° C. At these two temperatures the R_F values show a decrease instead of an increase compared with those at preceding temperatures. A decrease of the partition coefficient at higher temperatures would partly explain an increase of R_F, assuming a constant value for the ratio of areas of cross-section of the mobile and immobile phases.

The decrease in R_F values in the case of pyridine–water at 25° C. and *iso*propyl alcohol–water (7 : 3) at 30° C. is contrary to what one expects from the above reasoning. It is perhaps necessary to take into account a large number of factors involved in paper chromatography which are likely to be influenced by temperature. They include water-adsorption by cellulose, compositions of the phases, affinity of the solvent and solute molecules for cellulose and the solvating power of the liquids employed. A detailed study for evaluating the most likely factors is in progress.

Thanks are due to Dr. J. K. Chowdhury, head of the Department of Chemistry, and Dr. B. Banerjee, senior research fellow, Bose Research Institute, Calcutta, for their encouragement and suggestions during this work. My thanks are also due to Dr. S. K. Mukherjee, University College of Science and Technology, Calcutta, for his criticism and suggestions.

D. P. Burma

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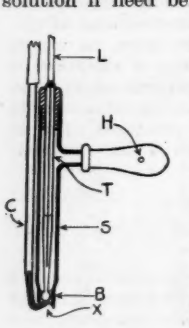
Calcutta 9.

[1] Consden, R., Gordon, A. H., and Martin, A. J. P., *Biochem. J.*, **38**, 224 (1944).
[2] Williams, R. J., and Kirby, H. M., *Science*, **107**, 481 (1948).

A Convenient 'Hanging-drop' Glass Electrode Unit

A glass electrode unit developed in this laboratory has proved so generally useful that its brief description may be helpful to others. It combines the advantages of providing a robust and convenient assembly for general purposes, and of permitting precise measurement of *p*H with as little as 0·15 ml. of available solution if need be. The form of the unit (which incorporates an effective stirring device) makes it suitable for electrometric titrations on volumes of solution as small as 0·4 ml.



The construction of the electrode assembly is shown in the diagram. The glass membrane is the bulb *B*, about 4·8–5·0 mm. diameter, blown on the end of the drawn-out tube *T* which contains a sealed-in *N* hydrochloric acid/silver chloride half-cell. It is a great advantage that the membrane consists of a type of glass permitting determinations of *p*H in alkaline as well as acid solution.

The electrode is mounted within a glass sleeve *S*, of which the main upper portion is 8 mm. internal diameter, and the short bottom portion about 6·2 mm. A side tube near the top is fitted with a rubber teat; this is perforated by a small hole *H* normally closed by the thumb on compressing. This provides a means of filling, washing, and also of stirring when the electrode is dipped into a small volume of liquid.

The bottom of the sleeve is open. A small notch ground in its bottom edge receives the bent tip of the potassium chloride bridge *C*, which is bound to the sleeve by rubber bands. The tip of *C*, including the bend, consists of a capillary with a sealed-in thread of asbestos fibres which terminates the salt bridge. The tube *C* is connected above to a reservoir (not shown) of potassium chloride into which a small calomel half-cell is dipped, the connexion being made through a length of about 12 cm. of flexible plastic tubing.

The potassium chloride reservoir, and the electrical lead *L*, are clamped on a suitable stand and the electrode assembly is allowed to dangle at a convenient height above bench-level.

The test solution *X* surrounds the glass electrode *B* and is held in place merely by capillarity. It is in contact with the tip of the potassium chloride bridge.

The general method of operation will be clear to any user, but the following may be mentioned: (1) pointed pieces of filter paper may be used to drain the space around the electrode, for example, during washing; (2) to fill when minimal liquid is available, a drop placed at the bend in *C* will enter the space around the electrode.

I wish to acknowledge the helpful co-operation of Messrs. Doran Instrument Co., Ltd., Stroud, Glos, who assisted by developing an appropriate glass electrode for this unit.

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July 27.

A Gravimetric Estimation of the Carboxylic Acid Group in Cellulose

The electrochemical and ion exchange properties of cellulose and other insoluble polysaccharides are largely determined by the content of —COOH groups, so that their precise estimation becomes a matter of some importance. Davidson[1] has recently re-examined the various methods available for their determination, which are based either upon some form of acid–alkali titration, or upon the absorption of the basic dye methylene blue.

We consider most of the defects of these earlier methods are absent in the new method we now describe. The material is soaked in a saturated solution of uranium acetate in water (*c.* 0·01 *M*, *p*H 6·5) over-night, very thoroughly washed, oven-dried and weighed, ashed at 700° C. and the ash weighed as U_3O_8. This procedure applied to commercial 'Cellophane' gave the following results:

mgm. Ash/1 gm. 'Cellophane'	13·56	13·86	13·97
Acid-washed blank	0·1	0·1	0·1

Mean COOH content milliequiv./100 gm. = 4·60.

One of us (G. R. W.) has also estimated the uranium content by weighing in water before and after soaking in uranium acetate, using a hydrostatic balance. An average result of 4·71 milliequiv. COOH/100 gm. was obtained.

The same material gave the following results by other methods:

Neale and Stringfellow's method (ref. 2)	4·76
Methylene blue absorption (ref. 1)	4·805
Pacsu's method (ref. 3)	5·02

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[1] Davidson, Shirley Inst. Mem., **22**, 71 (1948).
[2] Neale and Stringfellow, *Trans. Farad. Soc.*, **33**, 881 (1937).
[3] Pacsu, *J. Text. Research*, **16**, 163, 318, 390 (1946).

William Nicol and Henry Clifton Sorby

In her short article on William Nicol and H. C. Sorby, Mrs. Eyles states[1] that Nicol "seems to have confined himself to making sections of fossil wood, and did not make rock sections". Nicol stated in 1834[2], however, that when he came to prepare sections of fossil plants he "had recourse to a process I had practised upwards of fifteen years ago, in preparing thin slices of the most fragile substances, as calcareous spar, in order to examine their effects on polarized light". The lapidary G. Sanderson had made thin sections after fixing the specimen to a

block of wood with lapidary's cement; Nicol's process was essentially to substitute glass for wood and Canada balsam for the cement.

Nicol's collection in the British Museum (Natural History) contains, in addition to petrified plants, a few sections of flint and other pebbles, as well as of coal, cannel and lignite. Alexander Bryson's largely contemporary collection, also in the British Museum, includes sections of various minerals and rocks, and of corals and other fossil animals. There are incidental references to thin slices of minerals in some of Brewster's papers, and the technique had evidently been employed in Edinburgh on a wide range of minerals, rocks and fossils for many years before Sorby came on the scene, even if its applications were not pursued very far, except in the case of petrified plants.

Sorby's 1851 paper dealt with certain sedimentary rocks; but W. C. Williamson, from whom Sorby learnt the technique of preparing thin sections, had already in his classic memoir on "Microscopic Objects in the Mud of the Levant" (1848)[3] examined "thin sections of oolitic limestones from Bristol, Durdham Down, Yorkshire and Skerry". Williamson's interests were primarily biological; but his pioneering efforts are worthy of remembrance in any account of the early history of the microscopic study of rocks.

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[1] *Nature*, **168**, 98 (1951).
[2] *Edin. New Phil. J.*, **16**, 157 (1834).
[3] *Mem. Manchester Lit. Phil. Soc.*, (2), **8**, 99 (1848).

My article on Nicol and Sorby was intended to direct attention to two centenaries of especial interest in the history of microscopic petrography, that is, the examination of thin sections of *rocks*, which are, in most cases, mineral aggregates. It is generally recognized that the initial impetus to the development of this most important branch of geology was given by Sorby in the papers to which reference is made in my article; and also that the polarizing prism invented by Nicol and used by Sorby played an essential part in the development of the new science.

Nicol's statement, quoted by Mr. Edwards, certainly shows that he had made thin sections of *minerals*, but so had other and earlier workers. Prof. W. T. Gordon gave a short account of the history of the examination of stony material by means of thin sections to the British Association in 1926[1]. He mentioned there that Brewster made slices of amethyst one-fiftieth of an inch thick as early as 1817. In fact, Brewster made use of thin slices or plates of minerals for his optical studies several years earlier[2].

I am indebted to Mr. Edwards for directing my attention to the paper published by W. C. Williamson in 1848 in which he refers to examining thin sections of oolitic limestone from several localities. Williamson's paper was read in November 1845, and it is worth noting that in August of the same year John Phillips read a paper to a Yorkshire society in which he also refers to the examination of calcareous rocks in transparent sections[3] (a fact unknown to me when I prepared my article). It therefore seems that the advantages of this technique were becoming known in the eighteen-forties, especially in northern England.

That many of the sections made by Nicol and Bryson are preserved in the British Museum (Natural History) has escaped the notice of previous writers on Nicol, and indeed seems to have been unknown even to C. D. Sherborn, in his "Where is the — Collection?" (Cambridge, 1940). Sherborn noted only that the Nicol and Bryson collections were sold in 1868, and not that they were acquired by the British Museum. An account of these and any similar collections would be useful and interesting, and might provide a clue to the relative priority of Sorby, Williamson, Phillips, and possibly others in this field.

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[1] Gordon, W. T., "The Preparation of Thin Sections (History)" Rep. Brit. Assoc., Oxford, 1926, 348 (London, 1926).
[2] Brewster, D., *Phil. Trans.*, **104**, Pt. 1, 187 (1814).
[3] Phillips, J., "On the Remains of Microscopic Animals in the Rocks of Yorkshire", Geol. and Polytechnic Soc. West Riding of Yorkshire (Leeds, 1846) (author's separate).

Could an Arms-Race End Without Fighting?

There have been only three great arms-races. The first two of them ended in wars in 1914 and 1939; the third is still going on. From so few events we cannot hope to draw any reliable conclusions by statistics. Let us instead see whether an analysis of motives throws any light on the problem. Arms, in peace-time, are intended to overawe possible enemies; therefore the motive of submission must come into the picture. Arms, in peace-time, in fact provoke possible enemies to prepare to defend themselves; so defensiveness must be taken into account. There is also considerable grumbling about the cost of rearmament. The behaviour of large groups of people is more regular and less capricious than the behaviour of individuals. It is instructive to regard large groups as deterministic, and to represent their behaviour by differential equations, provided that we remember that such a treatment is a caricature. The following simultaneous pair of equations were published[1] for that purpose in 1939.

$$dx/dt = ky\{1 - \sigma(y - x)\} - \alpha x + g, \quad (1)$$
$$dy/dt = lx\{1 - \rho(x - y)\} - \beta y + h. \quad (2)$$

Here t is time, x and y are the war-like preparations of the opposing sides, and the other letters are constants. Of these, k and l are positive 'defence coefficients', σ and ρ are positive measures of 'submissiveness', α and β are positive measures of the objection to the cost of rearmament; but g and h, which represent feelings, not about arms but about the treaty-situation, may have either sign. The names of the opposing nations do not appear, because the motives are supposed to be common to mankind; but the numerical values of the constants may differ from nation to nation.

The validity of these equations was reconsidered in more detail, and by comparison with more historical evidence, in a microfilm[2] published in 1947. The equations were found to be a tolerably good representation of what had happened. Better measures of x and y were introduced under the name of 'warfinpersal', which means the annual 'defence' expenditure divided by the annual earnings of a semi-skilled engineer. By the time that an arms-race had grown to alarming proportions, it was found to be difficult to distinguish the effects of α, β, g or h,

for they were swamped by the effects of k and l. The ratio of k to l was reasonably regarded as equal to the ratio of the 'sizes' of their two respective groups as measured by population and industrial development.

The coefficients σ and ρ were originally introduced to represent the well-known fact that great Powers have sometimes suppressed very much smaller Powers without any fighting. The present note is about a comparatively subtle question, namely, the effects of submissiveness between two Powers that are in some sense equal. It will now be shown that the above equations (1) and (2) indicate the possibility that an arms-race might end without any fighting. I first noticed this theoretical possibility in April 1951. A preliminary note about it has been sent to Prof. C. C. Lienau of Columbia University for his book on "Measures of Organization".

The present world-tension between the devotees of communism and of private enterprise is between two groups sufficiently nearly equal to be alarmed about each other. For the sake of mathematical simplicity, let us represent this approximate equality by setting $k = l$, $\alpha = \beta$, $\sigma = \rho$; and let us neglect g and h. Equations (1) and (2) then become

$$dx/dt = ky - k\sigma y^2 + k\sigma xy - \alpha x, \quad (3)$$

$$dy/dt = kx - k\sigma x^2 + k\sigma xy - \alpha y. \quad (4)$$

It happens to be easier to discuss $(x + y)$ and $(x - y)$ rather than x and y separately. From (3) and (4) by addition and subtraction it follows that:

$$d(x + y)/dt = (k - \alpha)(x + y) - k\sigma(x - y)^2, \quad (5)$$

$$d(x - y)/dt = -(k+\alpha)(x-y) + k\sigma(x^2-y^2). \quad (6)$$

The relations are further clarified by dividing (5) and (6) respectively by $(x + y)$ and $(x - y)$; for then

$$d \log (x + y)/dt = (k - \alpha) - k\sigma(x - y)^2/(x + y), \quad (7)$$

$$d \log | x-y | /dt = -(k + \alpha) + k\sigma(x + y). \quad (8)$$

There was a time, during 1945 or 1946, before the present arms-race began to be mentioned. It may, nevertheless, have existed in embryo unnoticed, on one hand in Russia's tardy demobilization, and on the other in the United States' secrecy about the atomic bomb.

For mathematical simplicity it is convenient to contemplate an origin of time, say t_0, at which x and y were positive but both so near to zero that the last terms in (7) and (8) were negligible, leaving approximately:

$$d \log (x + y)/dt = k - \alpha, \quad (9)$$

$$d \log | x - y | /dt = -(k + \alpha). \quad (10)$$

The second member of (10) is negative, so that $\log | x - y |$ was tending towards minus infinity, and therefore x was tending to equal y. This is the equality of power, which many people rashly regard as a security. The second member of (9) is positive, so that $\log (x + y)$ was increasing. This is the arms-race beginning slowly and inconspicuously.

Next let us contemplate various later times at which $(x - y)$ is practically zero, but $(x + y)$ has grown enough to make the arms-race noticeable. In this stage the last term in (7) is more negligible than it was at t_0, because after t_0 its numerator has decreased, while its denominator has increased. So, in accordance with (9), the sum $(x + y)$ continues to increase exponentially. Therefore, a critical time, t_1 say, arrives after which $k\sigma(x + y)$ becomes greater than $k + \alpha$, thus making $d \log | x - y | /dt$ become positive. But because $d | x - y | /dt = | x - y | \cdot d \log | x - y | /dt$, and because $(x - y)$ is practically zero at t_1, there may be a long lingering after t_1 before $(x - y)$ deviates notably from zero. In other words, $(x - y)$ has been in equilibrium at zero, and at t_1 this equilibrium becomes unstable, so that a chance disturbance may cause either x to exceed y, or y to exceed x. The national politicians would be chiefly interested in which of these two ways the change began; but to that question the answer given by the equations would be untrustworthy, because of chance. The cosmopolitans and the non-politicals might have more cause to remember the subsequent changes described in the next paragraph.

Equation (7) shows that immediately after t_1 the sum $(x + y)$ goes on increasing. Yet, when $(x - y)$ has deviated sufficiently from zero, there will come a second critical time, t_2 say, after which $k\sigma(x - y)^2/(x + y)$ will become greater than $(k - \alpha)$, thus making $d \log (x + y)/dt$ negative. But because $d(x + y)/dt = (x + y).d \log (x + y)/dt$, and because $(x + y)$ is large and positive, the change in $(x + y)$ after t_2 will come on without delay. The contrast between these two reversals may be expressed by saying that $(x - y)$ was in equilibrium at t_1, but $(x + y)$ was far from equilibrium at t_2. The decrease of $(x + y)$ would be obvious as the end of the arms-race.

Both these theoretical reversals are consequences of submissiveness, for they would not occur if σ were zero in (7) and (8).

So say the equations (3) and (4). But could events really happen thus? As far as I know, they never yet have done so. Nevertheless, as the more general theory (1) and (2) has been verified in several other cases, it seems desirable that the topical case (3) and (4) should be published for discussion before the actual event becomes known.

The foregoing description is likely to be received with general incredulity, because it asserts, after the manner of Bertrand Russell's 1914 pamphlet called "War the Offspring of Fear", that the motives in the present arms-race are mutual; whereas the reader, whether he believes the capitalist or the communist propaganda, has been told that the arms-race is all due to the aggressiveness of the other side. I can scarcely hope to dispel a prejudice that is so natural anyway, and is daily reinforced by broadcasts and newspapers. Some evidence about present mutuality has been brought back from the U.S.S.R. by Prof. Kathleen Lonsdale.

There may be among the learned another quite minor cause of incredulity, namely, that the above simple argument is mainly about maxima and minima, and does not give a fully quantitative solution of the differential equations (3) and (4). These do not belong to any of the simple types treated in the text-books. Indeed, it seems remarkable that one can obtain considerable insight by a discussion of maxima and minima. The equations have, however, been integrated numerically in a particular case, and some approximate formulæ have been found. The constants have been roughly determined thus: $\alpha = 2$ year^{-1}, $k = 4$ year^{-1}, and perhaps $\sigma > 0{\cdot}4$ per million people. But an account of these doings might easily double the length of this article.

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Argyll.
Aug. 29.

[1] Richardson, L. F., *Brit. J. Psychol., Mon. Supp.* No. 23, p. 23, equations (31) and (32) (1939).

[2] Richardson, L. F., "Arms and Insecurity", a book in 35-mm. microfilm (published by the author, 1947 and 1949).

FORTHCOMING EVENTS

Monday, October 1

SOCIETY OF ENGINEERS (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. S. F. Smith: "The Application of Electronic Instruments to Industry".

Tuesday, October 2

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS (at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2), at 5 p.m.—Dr. J. Swaffield and Mr. D. L. Richards: "Transmission Performance of the Telephone Network—a Survey of some Basic Problems".

Wednesday, October 3

INSTITUTE OF PETROLEUM (at Manson House, 26 Portland Place, London, W.1), at 5.30 p.m.—Prof. F. H. Garner: "The Training of a Technologist" (Redwood Lecture).

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 7 p.m.—Scientific Papers.

Thursday, October 4

TEXTILE INSTITUTE, LANCASHIRE SECTION (at 16 St. Mary's Parsonage, Manchester), at 6.30 p.m.—Mr. G. K. Lake: "Developments of the New Synthetic Fibres in the U.S.A.".

Friday, October 5

ROYAL STATISTICAL SOCIETY, INDUSTRIAL APPLICATIONS SECTION, LONDON GROUP (at the E.L.M.A. Lighting Service Bureau, 2 Savoy Hill, London, W.C.2), at 6 p.m.—Mr. L. S. Valiance: "An Experiment on the Accuracy of Time Studies".

BRITISH INSTITUTION OF RADIO ENGINEERS, SCOTTISH SECTION (at the Institution of Engineers and Shipbuilders, Elmbank Crescent, Glasgow), at 7 p.m.—Dr. E. G. Richardson: "Acoustics in Relation to Radio Engineering."

Friday, October 5—Saturday, October 6

PHYSICAL SOCIETY (in the Physics Department of the Royal Cancer Hospital, Fulham Road, London, S.W.3).—Meeting to be held on the occasion of the Centenary of the Royal Cancer Hospital, 1851–1951: "Applications of Physics in the Diagnosis and Treatment of Cancer".

Friday, October 5.—At 2.30 p.m.

Saturday, October 6.—At 10 a.m.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER (Grade III) and a LECTURER (Grade II) IN THE DEPARTMENT OF BOTANY—The Secretary, The University, Edmund Street, Birmingham 3 (October 6).

CHEMISTS, METALLURGISTS and PHYSICISTS (Scientific Officer grade) at a Ministry of Supply research establishment near London, and (for one of the posts under Ref. F.582/51/A) the Royal Aircraft Establishment, South Farnborough, Hants: (Ref. F.582/51/A) PHYSICAL METALLURGISTS (3) with research experience in metallography, electron microscopy or X-ray or electron diffraction techniques, for the determination of thermal and physical properties of metals and alloys; (Ref. F.583/51/A) PHYSICAL CHEMIST or PHYSICIST, with an interest in metallurgy or ceramics, for research investigations connected with the preparation of novel ceramic materials; (Ref. F.584/51/A) PHYSICAL CHEMIST or PHYSICIST, with experience of electron diffraction techniques or of electrochemistry, for work on surface phenomena and for research investigations into the properties of metallic films and coatings—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (October 6).

RESEARCH ASSISTANT (graduate in chemistry, with biological interests) for work in connexion with an investigation into silicosis—The Registrar, The University, Reading (October 6).

SECRETARY TO THE COLLEGE—The Secretary, King's College, Strand, London, W.C.2 (October 8).

LECTURER IN PHYSICS (preference will be given to candidates interested in mathematical physics)—The Clerk to the Governors, Chelsea Polytechnic, Manresa Road, London S.W.3 (October 12).

RESEARCH APPOINTMENT (physics graduate) in Microwave Spectroscopy—The Secretary and Registrar, University College, Southampton (October 15).

RESEARCH FELLOW (with at least two years postgraduate experience in Theoretical Physics, Applied Mathematics, or Metal Physics) to WORK IN THE DEPARTMENT OF METALLURGY on theoretical problems concerning the structure and properties of metals—The Secretary, The University, Edmund Street, Birmingham 3 (October 15).

LECTURER IN PRODUCTION ENGINEERING subjects, including workshop technology up to Higher National Certificate standard, at Denbighshire Technical College, Wrexham—The Director of Education, Education Offices, Ruthin (October 20).

SENIOR RESEARCH OFFICER (with a university degree with honours in chemical or mechanical engineering, or equivalent qualifications, and with experience in the construction and operation of industrial plant) to undertake the planning and supervision of the design, construction and operation of pilot scale complete gasification plants, in the Division of Industrial Chemistry, Commonwealth Scientific and Industrial Research Organization, Fishermen's Bend, Melbourne—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 3508 (October 20).

VETERINARY RESEARCH OFFICERS (who must be members of the Royal College of Veterinary Surgeons, or hold a degree in Veterinary Science of an approved university involving a five-year course) in the Research Branch of the Department of Veterinary Service, Southern Rhodesia—The Secretary, Office of the High Commissioner for Southern Rhodesia, 429 Strand, London, W.C.2 (October 31).

LECTURER (with university degree or diploma either in engineering or agriculture) IN AGRICULTURAL ENGINEERING at Canterbury Agricultural College, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (November 12).

CHAIR OF APPLIED PHYSICS at New South Wales University of Technology—The Agent-General for New South Wales, 56 Strand, London, W.C.2 (November 30).

ASSISTANT (Grade B) IN THE DEPARTMENT OF METALLURGY AND CHEMISTRY at Rotherham Technical College—The Director of Education, Education Offices, Domine Lane, Rotherham.

BOTANIST or PLANT PATHOLOGIST for the Research Division of the Ministry of Agriculture in the Sudan—The Sudan Agent in London, Wellington House, Buckingham Gate, London, S.W.1, endorsed 'Botanist/Plant Pathologist 4/403'.

CHEMISTS (Principal Scientific Officer grade) at a Ministry of Supply research and development establishment in Buckinghamshire, to work on problems of combustion in solid and liquid propellant rocket motors—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.650/51/A.

DEMONSTRATOR IN CHEMISTRY—The Registrar, The University, Nottingham.

HEAD OF THE BUILDING DEPARTMENT (Grade I) at Burton-on-Trent Technical College—The Director of Education, Education Offices, Guild Street, Burton-on-Trent.

INSTRUMENT ENGINEER (with an honours degree in engineering, corporate membership of one of the Institutions of Mechanical or Electrical Engineers, or equivalent qualifications, and with at least three years practical experience of instrument manufacture) to undertake the design, provision and maintenance of instruments used for the measurement of radioactivity and for the control and recording of pressures, temperatures and the flow of liquids and gases, using electronic and other methods, at the Division of Atomic Energy (Production), Risley—The Ministry of Supply, D.At.En.(P.), Risley, Warrington, Lancs.

LECTURER IN THE DEPARTMENT OF ENGINEERING at the County Technical College, Wednesbury—The Director of Education and Clerk to the Governors, Dept. F.E., County Education Offices, Stafford.

MATHEMATICIAN (Senior Experimental Officer or Experimental Officer grade) to take charge of, organize and build up a small computing section, and a MATHEMATICIAN (Experimental Officer or Assistant Experimental Officer grade) with interest in applied mathematics or numerical analysis, for a Ministry of Supply research and development establishment south-east of London—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.254/51/A.

PREHISTORIAN (with a good honours degree in archæology) for the Department of Geological Survey, Uganda—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27079/57/51.

RESEARCH OFFICER (BIOCHEMIST, with science degree of United Kingdom University and at least two years postgraduate biochemistry experience) for service in Kenya, Tanganyika and Uganda—The Under-Secretary of State, Research Department, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1.

SENIOR LECTURER qualified to teach some of the following subjects: Theory and Design of Structures, Surveying and Levelling, Building Science, Strength of Materials up to Higher National Certificate standard in building and civil engineering, and a LECTURER IN THE MECHANICAL ENGINEERING DEPARTMENT to teach Production Engineering up to at least Higher National Certificate standard—The Secretary, South-East London Technical College, Lewisham Way, London, S.E.4.

SENIOR RESEARCH OFFICER (with membership of the Royal College of Veterinary Surgeons or equivalent, and a university degree, preferably in Veterinary Science, and at least six years experience in veterinary research work), and a RESEARCH OFFICER (with membership of the Royal College of Veterinary Surgeons or equivalent, and a university degree, preferably in Veterinary Science), in the Sudan Veterinary Service—The Sudan Agent in London, Wellington House, Buckingham Gate, London, S.W.1, marking envelope 'Research Officer 4/220'.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Colonial Office. Colonial Research 1950–1951: Reports of the Colonial Research Council, Colonial Products Research Council, Colonial Social Science Research Council, Colonial Medical Research Committee, Committee for Colonial Agricultural, Animal Health and Forestry Research, Colonial Insecticides Committee, Tsetse Fly and Trypanosomiasis Research Committee, Colonial Fisheries Advisory Committee, Director, Anti-Locust Research Centre. (Cmd. 8303.) Pp. 243. (London: H.M. Stationery Office, 1951.) 6s. 6d. net. [78

Fifth Column Psychology. By Vivian U. M. Thompson. Pp. 16. (Lightwater, Surrey: The Author, Ratawi, 1951.) 2s. [78

Annual Reports on the Progress of Chemistry. Cumulative Index, Vols. 1–46, 1904–1949. Pp. 286. (London: Chemical Society, 1951.) 25s. [78

Question. Vol. 3, No. 3: People at Work. By E. W. Hughes, R. W. Latham and Winifred Raphael. Pp. 185–256. (London: Hammond, Hammond and Co., Ltd., 1951.) 2s. 6d. [78

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